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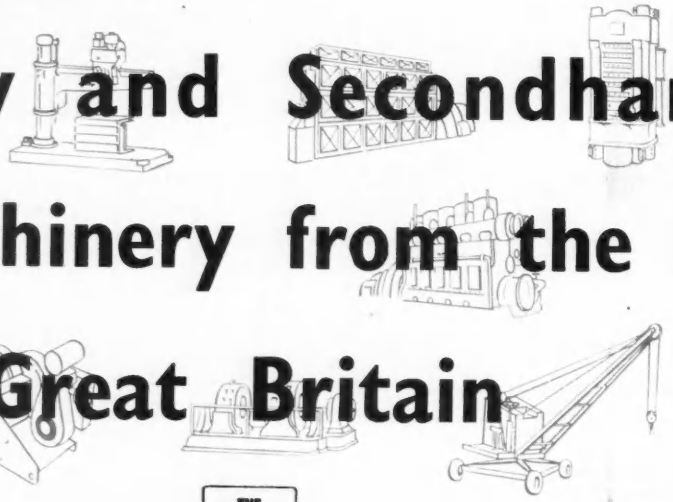

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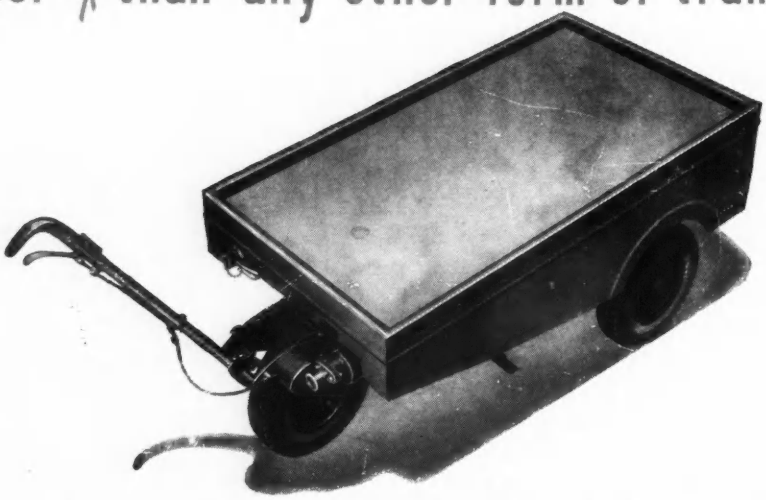

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THE ENGINEER

JANUARY 21, 1955

British Tractors in America

AT a meeting of the Institution of British Agricultural Engineers, which was held in London on Tuesday of last week, Mr. Tom Gilling gave an address on the sale and utilisation of British manufactured agricultural tractors in the U.S.A. Mr. Gilling recently spent several weeks in America in order to find out why it was that there was now a considerable demand for British tractors in a country which has always produced more tractors than anyone else in the world and which certainly has the biggest tractor population. In his address, he submitted that the basic reason of the appeal of British tractors to American farmers was economic. It was cheaper to operate a diesel-engined tractor of around 40 h.p. than to operate a petrol one, and, in spite of the lengthy shipping and land transport haul from Britain, an American farmer could buy a British diesel-engined tractor anything from 200 to 300 dollars more cheaply than he had to pay for an American petrol-engined tractor of comparable horsepower. Mr. Gilling went on to say that it was in the industrial field in the U.S.A. that the British diesel tractor "really impressed." He quoted a New Orleans contractor, operating a tractor-driven hydraulic loader on "tough road and similar construction work," who explained that he was saving up to 7 dollars a day on fuel cost with the British diesel when compared with an American petrol-engined tractor of 40 h.p. About the prospects of selling British tractors and agricultural machinery in the U.S.A., Mr. Gilling said that where there was big business to be gained, there must be big service with it. He went on to describe the excellent equipment installed in various dealers' workshops which he had visited during his tour, and emphasised that anything short of adequate after-sales service would do any British maker, and, indeed, this country, far more harm than good in the U.S.A.

International Geophysical Year

THE Royal Society says that a world-wide co-ordinated study of the natural physical forces of the earth has been planned to be made over the period from July, 1957 to December, 1958, which will be known as the "International Geophysical Year." Scientists from thirty-six nations will participate in this combined operation, the cost of which has been estimated at about £35,000,000. The "Year" has been chosen to coincide with a period of maximum solar activity, when sun spots and solar eruptions will be numerous. This project has been initiated by the International Council of Scientific Unions and the responsibility for preparing the detailed plans is in the hands of a special international committee set up by the council, its chairman being Professor Sydney Chapman, F.R.S., formerly Sedleian Professor of Natural Philosophy in the University of Oxford. For the purpose of planning, arrangements are being made in relation to the following six regions of the earth—the Antarctic, the Equator, the Arctic, and three North to South Pole zones, one passing through Europe and Africa, another through the continent of America and the third through the U.S.S.R., Japan and Australia. Steps are being taken to ensure that there are adequate numbers of stations in these areas. Existing stations will be used as far as possible but new ones will also be set up to bridge any gaps in the network. Because many of the forces acting on the earth are dependent on the sun, there will be a continuous patrol of solar activity on a world network of astronomical observatories. This will be linked to observations which radio scientists will make to record the activity in the ionised layers of the upper atmosphere. Another important geophysical phenomenon is the appearance of aurorae in the polar regions and a very close watch will be maintained by visual, photographic and radio methods. The balloon-carried radio sonde and the newly-developed British radar sonde will be among the instruments which the meteorologists will use to make records of weather phenomena. For a study of the upper atmosphere another instrument to be used will be the rocket and it is proposed to launch from land and sea rockets which will take samples of the upper atmosphere and make direct observations of the sun, some of which are only possible when the lower atmosphere is penetrated. In order to co-ordinate British participation in the programme, the Royal Society has set up a British national committee under the chairmanship of Mr. J. M. Wordie, Master of St. John's College, Cambridge.

Conway Bridge

WE are informed that the Minister of Transport and Civil Aviation, Mr. John Boyd-Carpenter, will soon formally inaugurate work on the new Conway road bridge which will replace the suspension bridge built by Thomas Telford in 1826. The new bridge, which will be free from tolls, is to be built by Sir William Arrol and Co., Ltd., whose tender for £430,700 has been accepted. The entire cost will be met by the Ministry. When completed in about two and a half years, the new bridge will carry the Chester–Bangor trunk road (route A55) over the River Conway. It will be separated from the existing suspension bridge on the north or estuary side of the river by about 60 yards, and will have a single span of 310ft, carried on four spandrel-braced steel arch ribs. The overall width between parapets will be 31ft 6in, providing for a single 22ft carriageway, a 7ft 6in footpath on its northern side, and a 2ft reserved strip on the south side. With the approaches to the bridge the total length of carriageway in the contract is over a quarter of a mile. The bridge has been designed, it is stated, to harmonise with the historic background of Conway Castle and the mediæval character of the town, and in these aspects it has the approval of the Royal Fine Art Commission. Sir Percy Thomas is the consulting architect, and Mr. H. W. FitzSimons the consulting engineer. The design is also suitable for widening at a later date. The present bridge may be used only by single-line spaced-out traffic with a weight limitation for vehicles, and a 5 m.p.h. speed limit. Since 1878 it has been in the custody of the Conway Bridge Commissioners, and a toll is levied on vehicles using the bridge for the upkeep of the structure.

Aircraft Production Conference

THE third annual conference on the problems of aircraft production was held on Friday and Saturday of last week at the University of Southampton. It was organised by the Southern Section of the Institution of Production Engineers. The theme of this year's conference was entitled "Integral Construction Contrasted with Traditional Methods." There were five papers, each followed by a discussion. During the first session on Friday, Mr. A. E. Woodward Nutt read a paper entitled "Aircraft Design Problems and Trends," in which he postulated the advantages and disadvantages of the trend suggested by the theme of the conference. Speeches at the luncheon which followed were made by the Mayor of Southampton and Sir Edward Boyle, Bt., Parliamentary Secretary to the Ministry of Supply. The chairman was Mr. West, Principal of Southampton Technical College. During the afternoon session Mr. R. S. Brown, of High Duty Alloys, Ltd., addressed the conference on the "Problems of Forging," discussing such new aspects as were introduced by large forgings in high-strength aluminium alloys. Mr. G. W. Richards and Mr. E. D. Keen, of Armstrong-Whitworth Aircraft, Ltd., read a combined paper on "Machining and Forming Problems of Integral Construction." The Saturday morning session opened with a paper by Mr. S. Radcliffe on "High-Speed Machine Tools for Aircraft Production." The conference concluded with a paper by Mr. W. E. W. Petter, managing director and chief engineer of Folland Aircraft, Ltd. His paper was entitled "Where Do We Go From Here?" and is reproduced in its entirety on page 100.

James Watt International Medal

IT is announced that the Institution of Mechanical Engineers has awarded the 1955 James Watt International Medal to Dr. Igor Ivan Sikorsky, in recognition of his life's work in applying science to the progress of mechanical engineering through pioneering development of aircraft of various kinds, particularly helicopters. The James Watt International Medal was founded to commemorate the bicentenary of the birth of James Watt on January 19, 1736. It is awarded every two years to an engineer of any nationality who is deemed worthy of the highest award the Institution can bestow and that a mechanical engineer can receive. In making the award the principal engineering societies and institutions in all parts of the world co-operate with the Institution of Mechanical Engineers as nominating authorities. The Institution points out that to be worthy to receive a medal struck in commemoration of one who was at the same time a scientist, and inventor and a producer, the recipient himself should be an engineer who has achieved international recognition both by his work as a mechanical engineer and by the ability with which he has applied science to the progress of mechanical engineering. The Institution recognises, however, that only rarely will it be possible to find men in whom these qualities are so equally balanced as they were in James Watt. It therefore considers for the award men who have attained world-wide eminence in mechanical engineering in any direction—science and research, invention and production.

Conference on Combustion

IN our issue of October 8th last, we made a preliminary announcement about a conference on combustion which is being arranged jointly by the Institution of Mechanical Engineers and the American Society of Mechanical Engineers. This conference will be held in two parts, the first being at the Massachusetts Institute of Technology, Cambridge, U.S.A., from June 15th to 17th inclusive. The second part of the conference will be held at the headquarters of the Institution of Mechanical Engineers, Birdcage Walk, London, S.W.1, from October 25th to 27th. The same papers will be presented at both parts of the conference. The main objects of this conference are to link theory with practice in the sphere of combustion by presenting the results of theoretical work to practical engineers in the U.S.A., Great Britain, and other countries, and to provide an opportunity for practical engineers in those countries to meet together to discuss practical applications of theory in the fields of boilers, furnaces, internal combustion engines and gas turbines. Some fuller information about the conference, which has just been issued, shows that the discussions will be based on about forty papers classified in five sections as follows :—general, boilers, industrial furnaces, internal combustion engines, and gas turbines. The American Society of Mechanical Engineers has extended an invitation to members of the Institution of Mechanical Engineers to take part in the American conference. The Institution says that it is able to make travel arrangements for any of its members who wish to go to Boston for the conference.

Comparison of Electrical Properties of Various Cements and Concretes

By E. HAMMOND* AND T. D. ROBSON*

No. I

Details are given here of direct comparisons, which were made under exactly similar conditions, of the electrical properties of concretes using three different kinds of cement—ordinary Portland cement, rapid hardening Portland cement and high-alumina (aluminous) cement. Mention is made of the steps taken to reproduce the same test conditions throughout the experimental work to ensure that the results would be comparable. Comparative values of resistance, capacitance and electrical strength are given. Most of the measurements were made on relatively mature cements and concretes but some were made during the early curing period.

COMPARATIVELY little work has been done on the electrical properties of hardened cements and even less information is available about concretes. This is perhaps not surprising since the determination of any single property (e.g. volume resistivity) is surrounded by difficulties. The characteristics of the cement alter to an enormous extent throughout the setting, hardening and subsequent drying-out process, and a wide variety of test instruments is required to provide reasonably accurate information at the various stages. The relative importance of such factors as polarisation, capacitance, &c., varies considerably with the age and degree of humidity of the concrete. Furthermore, the electrical properties may vary throughout the specimen of concrete because (*a*) concrete is itself a heterogeneous material ; (*b*) stratification occurs during placing and (*c*) subsequent drying-out takes place preferentially from the exposed surfaces, resulting in a " humidity gradient " from the centre to the outside.

Accordingly, widely varying results may be obtained by different investigators unless all factors including size and shape of specimen are carefully duplicated. With this in mind, the present work has been confined to a direct comparison, under exactly similar conditions, of concretes made with three different types of cement—ordinary Portland cement, rapid hardening Portland cement, and high-alumina (aluminous) cement. The only concrete mix employed consisted of four parts by weight of flint gravel ($\frac{3}{4}$in-$\frac{3}{16}$in), two parts by weight of silica sand ($\frac{3}{16}$in down), one part by weight of the appropriate cement, and 0·49 parts by weight of water. Comparative data on specimens of the neat cements (W/C=0·235) were also obtained.

Previous Work

Previous work has mainly been with cement pastes and has been directed towards obtaining information about the changes in electrical resistance during the setting process.

Among the earlier workers in this field were Shimizu,[1] Baire,[2] Akashi,[3] Petin,[4] Kind[5] and Dorsch.[6] The latter, working with pastes of different types of cements, found that the electrical resistivities were in reverse order to the lime contents of the cements tested. The same author also showed that, in the short period covered by his tests, a decrease in the water-cement ratio from 0·40 to 0·25 corresponded to an increase in resistivity of approximately 15 per cent. A similar effect was recorded by Boast,[7] who also revealed the variation in resistivity of Portland cement paste at different heights in the specimen. It is of interest to note that he was unable to find a general correlation between the resistivities of sand mortars fifteen minutes after gauging, and their twenty-eight-day compressive strengths. Michelsen[8] and Jesser[9] utilised the galvanic effects of metals placed in the cement paste to investigate the change in electrical properties during setting.

Recently Calleja[10] has published curves showing the variation in resistance of Portland cement pastes setting under almost adiabatic conditions and he concluded that the determination of setting time by this process is superior to classical methods. In a later paper[11] he indicated that over a range of frequencies from 40-20,000 c/s, the resistance of the paste is decreased only slightly, the maximum decrease being of the order of 10 per cent.

The Division of Building Research C.S.I.R.O. (Australia) obtained a resistivity of 2·5–5·0 megohms-centimetres for a block of air-dried Portland cement paste,[12] and Maguire and Olen,[13] using a guard-ring technique, found that concretes (with siliceous aggregate), after oven-drying at 96 deg. Cent. for one day, had resistivities in excess of 10,000 megohms-centimetres at 700V. The same authors gave resistivities of 0·136–1·14 megohms-centimetres for mature concretes which were not artificially dried. Unfortunately, the age of the concretes was not stated.

The resistivities (during storage in air) of neat Portland cement and gravel concretes made with slag cement and Portland cement were investigated by Decoux and Barree.[14] The resistivity of specimens of neat Portland cement was much less than that of concrete. Addition of sodium chloride, calcium chloride, magnetic iron oxide, or iron turnings appreciably increased the conductivity. Yamada[15] and Ohama[16] have also given some data on resistivities in connection with work on the electrical heating of concrete, whilst Spencer[17] has investigated the relationship between electrical resistance and moisture content in mass concrete.

Preliminary Investigations

It is clear from a review of previous work that substantially different results for the resistivities of cements or concretes have been obtained even under reasonably comparable conditions. Many of the causes of this will become apparent throughout this account, but one of the main factors to be considered is the positioning of the electrodes. In many cases, it has been the custom to embed the electrodes in the concrete or cement such that the current only passed through the interior portion of the material. Preliminary experiments indicated that, during the curing period, the resistivity of the concrete or cement could be considered as being constant throughout the cubes. When allowed to harden under normal air-drying conditions, however, the resistivity of the material in the interior increased at a very much slower rate than that nearer the exterior faces, and this increasing difference was particularly evident in the case of the high-alumina cement concrete. The variation of the resistivity is, of course, due to the moisture gradient established in the cubes by air-drying. A further objection to the use of embedded electrodes, apparent from past work, is that it is a matter for conjecture which area should be used for calculating the volume resistivity, the area of the electrode or the cross-sectional area of the specimen.

It is therefore apparent that, to obtain a truly representative and practical value for the resistivity of hardened concrete and cement, it is necessary to ensure that the applied current traverses the whole of the specimen. This may be arranged by measuring the resistances of cubes or prisms of concrete using external electrodes identical in area and shape to the cross-section of the specimens. When no guarding provisions are included in this arrangement the measured resistance is, of course, the combined value of volume resistance and surface resistance. It was quite evident, however, from further preliminary experiments that during both the curing and air drying periods (up to 150 days), the surface resistances of the concretes and cements were of a much higher order than the corresponding volume resistances. Consequently, with specimens under these conditions, no guarding arrangements have been incorporated to pick up the small surface leakage since the measured resistance approximates very nearly to the volume resistance.

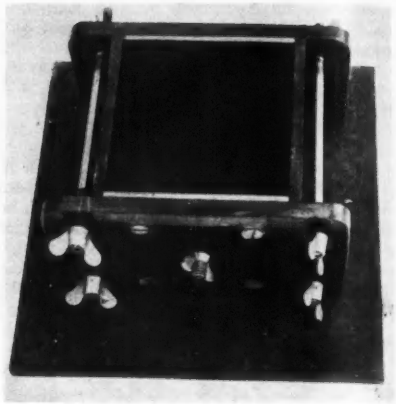

Fig. 1—Special mould (4in cube) fitted with electrodes

It is pointed out later on in this paper that a guard arrangement is essential with concretes or cements which have been subjected to elevated temperatures and subsequently cooled in the atmosphere.

Scope of Investigation

All the concrete and cement specimens have been initially cured at 60 deg. Fah. and 90 per cent relative humidity, the curing periods being seven days in the case of the Portland type cements, and one day for the high-alumina cement.

Apart from the preliminary experiments already referred to, a minor section of the main investigation has been carried out using 6in concrete cubes containing 3in square electrodes embedded centrally at a distance of 3in apart. In the majority of the work, however, the specimens used have been 4in concrete cubes or 4in by 4in by 1in neat cement prisms, fitted with 4in square external brass electrodes. The electrodes were mounted on insulating material and served initially as two sides of the 4in mould (Fig. 1). The remaining two sides of the

* Lafarge Aluminous Cement Company, Ltd.

mould were made of the same insulating material.

During the initial part of the curing period the resistance measurements were carried out whilst the concretes and cements were still in the mould. After they were sufficiently hard for the moulds to be removed, intimate contact between the electrodes and the specimen was made through a thin layer of a stiff paste of colloidal graphite as suggested in B.S. specifications.[18,19] Using this medium, good contact could be established by placing one electrode on top of the specimen which was supported by the other electrode.

The methods and circuits available for measuring the electrical resistance of materials are innumerable and vary according to the magnitude of the resistance to be measured and the other electrical properties of the material which have to be taken into account. The range of resistivity of concrete from time of placing to an appreciable age is very wide and no single method can conveniently be employed. At early ages, when the resistivity is comparatively low, a low voltage must be employed in order to minimise the current and the consequent heat development in the sample. At these ages, however, the effect of polarisation is very marked and if allowed to build up, the back E.M.F. may attain a value of the same order as the impressed voltage. These difficulties have been satisfactorily overcome by using over this lower range a test meter supplying its own small d.c. voltage and including in the circuit a switch

TABLE I—*Effect of Polarisation on the d.c. Resistance of Neat Cement Prisms* (4in×4in×1in)

(a) Resistance in ohms with reversing switch operating.
(b) Resistance in ohms (to direct current), 5 sec after reversing operation ceased.

Age in hours	High-alumina cement		Portland cement		Rapid hardening Portland cement	
	(a)	(b)	(a)	(b)	(a)	(b)
0	52	110	5	40	5	20
4	58	100	5	25	4	40
8	930	1200	6	40	6	20
12	1400	1560	7·5	44	7	50
16	1620	1700	8·5	26	9	37
20	1900	1900	11	37	14	38
24	1900	1900	15	40	17	36

which reversed the current approximately twice per second. The effect of polarisation is shown in Table I.

The higher resistances of the more mature specimens were measured by a "Megger" instrument, but the value of the oven-dried samples necessitated the use of a 500V d.c. insulating tester in conjunction with the guard ring technique. Additional results

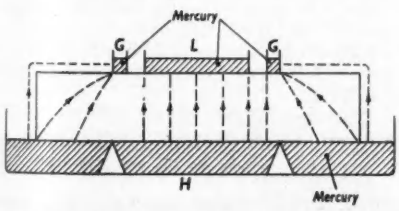

Fig. 2—Electrode arrangement for measuring volume resistance of a cement block (mercury electrodes)

on oven-dried samples submitted to the British Electricity Authority Research Laboratories, were obtained using the set-up and circuit shown in Figs. 2 and 3. The electrodes were arranged so that the guard electrode *G*, surrounded the low-voltage electrode, *L*, both of which were on top of the block whilst the high-voltage electrode covered the whole of the bottom of the block. For the determination of volume resistivity, the low-voltage and guard electrodes were virtually at the same potential so that the low voltage electrode only collected current flowing normal to it. The guard electrode collected the current which leaked over the surface of the block and also that which "fringes" the low-voltage electrode.

The method adopted was first to apply the voltage *V* to the resistance *R* with the sample

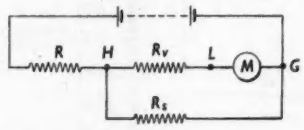

Fig. 3—Circuit for measuring volume resistance

short circuited so that the volume resistance $R_v=0$, and the surface resistance, $R_s=0$, and measure the current *I* through the galvanometer M.

Then

$$V=RI \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Then with the sample in circuit, the currents through R_v and R_s, (I_v and I_s), were measured by connecting the galvanometer first in series with R_v, as in Fig. 3, and then in series with R_s. The volume resistance could then be determined from the formula

$$R_v=R(I-I_s-I_v)/I_v \quad . \quad . \quad . \quad . \quad (2)$$

As a result of similar collaboration, the above laboratories also carried out breakdown tests on various specimens using high-voltage d.c. and a.c., and, when the resistance was comparatively low, impulse currents from a 1·4 MeV Marx generator.

The a.c. characteristics of the concretes and cements were determined by means of the circuit shown in Fig. 4 (due to Dr. J. White, of Sheffield University). This apparatus was capable of measuring simultaneously resistance and capacitance at frequencies up to 25kc/sec with great accuracy, and a fuller description has been given in a recent publication by Ford and White.[20] It consists essentially of a normal a.c. bridge employing a cathode-ray oscillograph as the null-point detector. The concrete or cement sample constitutes one arm of the bridge and may be considered to be a resistance, R_3, in parallel with a capacitance, C_3, which were balanced by the variable resistance and capacitance, R_4 and C_4. The resistances R_1 and R_2, served as the variable ratio arms.

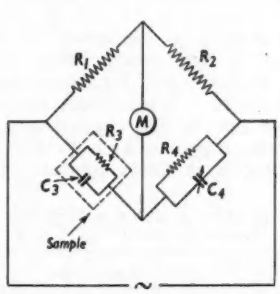

Fig. 4—The "parallel resistance" A.C. bridge

RESULTS

(*a*) *Resistivity.*—Although the main object of the work was to compare the resistivities of relatively mature cements and concretes, measurements have also been made during the early curing period. The results have indicated that good agreement was obtainable with specimens of the same kind of cement provided they were gauged and placed on the same day; hand-placed and vibrated cubes also showed good agreement. On the other hand, a fairly wide variation occurred with specimens gauged on different days which may be most likely attributed to the variation from day to day of the initial temperatures of the materials employed.

TABLE II—*Volume Resistivities (Ohms-Centimetres) of* 4 : 2 : 1 *Concrete* (*W*/*C*=0·49) *Made on Different Occasions with Seven Different Samples of High-Alumina Cement*

Age from time of gauging (hours)	First day			Second day			Fourth day		Fifth day		Eighth day	
	HA/1	HA/2	HA/3	HA/1	HA/2	HA/4	HA/2	HA/5	HA/2	HA/6	HA/1	HA/7
0	9,400	9,600	9,400	9,000	9,000	9,000	8,100	8,200	10,000	9,400	10,500	10,000
2	9,400	9,500	9,400	8,700	8,500	8,700	8,000	7,700	9,500	9,400	9,700	9,600
4	11,800	12,300	12,000	10,000	10,500	11,600	10,200	9,200	11,000	11,700	12,200	13,500
5	16,500	17,400	15,600	13,500	14,200	15,500	14,000	12,000	14,500	15,700	17,800	18,100
6	26,700	24,500	24,000	18,700	20,000	24,000	20,000	16,500	22,000	24,000	25,000	27,000
7	40,000	39,700	33,000	29,000	28,000	30,000	—	—	—	—	—	—
24	150,000	150,000	147,000	120,000	135,000	130,000	150,000	152,000	143,000	140,000	150,000	140,000

The above variations in resistivity include those due to differences in cement composition, fineness, &c., and those due to slight differences in the initial temperature of the aggregates. Immediately after gauging, all cubes were stored at 60 deg±1 deg. Fah. and over 90 per cent relative humidity.

The curves of Fig. 5 illustrate the development of the resistivity of the concretes and neat cements during the first twenty-four hours of the curing period. The maximum spread of the results from which the curves were drawn does not exceed approximately ±10 per cent, even though many specimens of each kind were tested. Thus, in the case of the high-alumina cement concrete, tests were carried out on more than thirty cubes made with seven samples of cement of varying chemical composition, fineness, &c. (Table II). The random nature and similarity of the results precluded their correlation with these properties. Consequently, it is not surprising that the results obtained with the two kinds of Portland cements, both for the neat cements and the concretes, did not warrant the drawing of separate curves (Table III). It may be noted from Fig. 5

TABLE III—*Volume Resistivities (Ohms-Centimetres) of* 4 : 2 : 1 *Concretes* (*W*/*C*=0·49) *Made from Normal and Rapid Hardening Portland Cements, During the First Twenty-Four Hours after Gauging*

Duplicate determinations were made on each cement.

Age from time of gauging (hours)	Portland cement		Rapid hardening Portland cement	
1	910	1010	890	920
4	1050	1160	990	1060
8	1230	1330	1180	1240
12	1450	1510	1410	1490
16	1740	1790	1790	1920
20	2000	2080	2120	2260
24	2370	2330	2280	2310

that the ratio of the resistivities of the high-alumina cement and the Portland cements, whether as neat cement or concrete, is approximately 10 : 1 from the time of initial placing up to the setting time. This value has been confirmed by Calleja.[21] After twenty-four hours of curing the ratio is approximately 100 : 1. The ratios of the resistivities of the concretes to those of the corresponding neat cements, vary over the first twenty-four hours of curing from approximately 5 : 1 to 3 : 1 for all the cements.

The development of the resistivities of previously cured concretes and neat cements, when allowed to dry out normally in the laboratory at room temperature is shown in

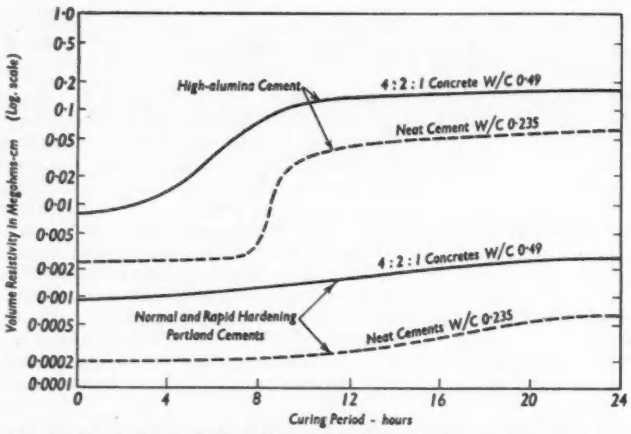

Fig. 5—Development of the volume resistivities of 4 : 2 : 1 concretes and neat cements during the first twenty-four hours of the curing period (60 deg. Fah. and >90 per cent relative humidity)

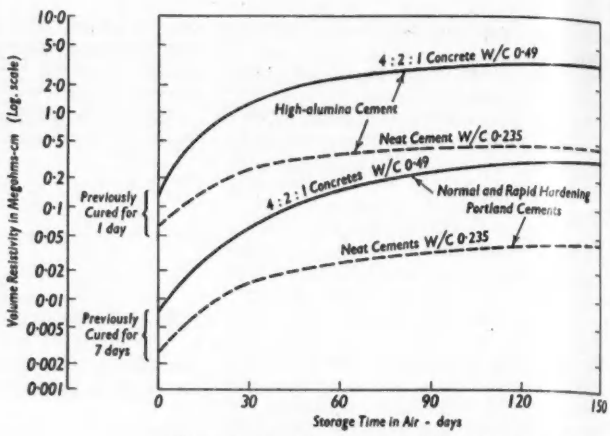

Fig. 6—Increase of volume resistivities of neat cements and 4 : 2 : 1 concretes when stored in air at room temperature

Fig. 6. It is evident from the figure that the ratio of the resistivities of the high-alumina and the Portland cements or concretes at the beginning of the drying period is approximately 20 : 1, whilst after 150 days the ratio is approximately 10 : 1.

Under certain conditions of service, it is conceivable that concretes or cements may be "artificially" dried to an appreciable extent. Determinations have therefore been carried out using specimens which have been oven-dried for periods of several weeks. Contrary to the properties of the normal air-dried samples, it was found that the surface resistances of the oven-dried concretes and cements were very much lower than the volume resistances and, therefore, for an accurate determination of the latter, a guard ring technique had to be adopted. It should be remembered, however, that the relative magnitudes of the two resistances are governed by the shape and size of the specimen under consideration.

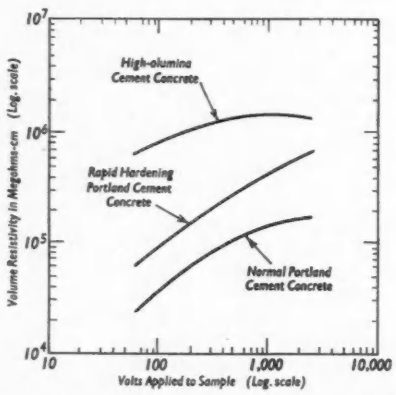

Fig. 7—Volume resistivities of 4 : 2 : 1 concrete after oven drying and cooling in desiccator

The curves of Fig. 7 show the effect of voltage on the volume resistivities of the three different concretes. After oven drying, the specimens were cooled in a desiccator and tested immediately after withdrawal. Mercury electrodes and very sensitive standard equipment were used (Figs. 2 and 3). An electronic d.c. insulation tester was used for check measurements with other oven-dried samples which had been allowed to stand for two days in air. The good agreement with the results obtained with the "desiccator" specimens, shown in Table V, indicates that any decrease in volume resistivity, which would result from the gradual absorption of moisture into the interior of the concrete, occurs very slowly.

TABLE V—*Volume Resistivities at 500V of Concretes Dried at 105 deg. Cent. and Cooled Under Different Humidity Conditions (Megohms-Centimetres)*

Cooling conditions	High alumina	Portland	Rapid hardening Portland
In desiccator	1,450,000	110,000	300,000
In the atmosphere ...	1,600,000	105,000	120,000
	2,200,000	75,000	—

As is to be expected, however, the storage conditions have a great influence on the surface resistance of the concrete. Thus, Fig. 8 shows the surface resistivities of oven-dried concretes and cements when measured immediately after cooling in a desiccator. Table IV compares these values at 500V with the corresponding results obtained with similar specimens which had been in contact for some days with the atmosphere.

From Tables IV and V it is apparent that, for the oven-dried specimens, the surface resistance is very much lower than the volume resistance and, for most shapes, this will govern to a large extent the effective resistance due to the combination of the two values experienced in practice. This relationship is in direct contrast with that obtained for mature concretes of all ages which had not been artificially dried. In the latter case, as mentioned previously, the volume resistance was much the lower value and, therefore, the main controlling factor. This may be accounted for by the fact that the moisture adsorption by the dried concrete surface in air will be very rapid and equilibrium soon attained, so that the surface resistance assumes a value of the same order as that of normally well-matured concrete. On the other hand, the migration of the moisture into the interior of the concrete will be very slow, coupled with the fact that the effect of drying will be to a large extent irreversible. The volume resistance of the dried concrete, therefore, tends to maintain its high value.

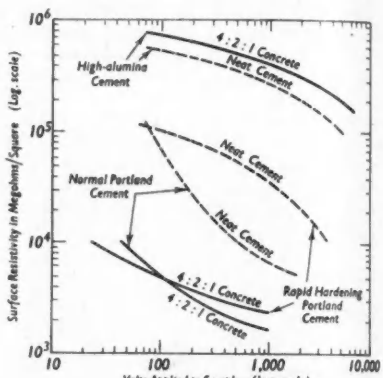

Fig. 8—Surface resistivities of neat cements and 4 : 2 : 1 concretes after oven drying and cooling in desiccator

TABLE IV—*Surface Resistivities at 500V of Concretes and Cements Dried at 105 deg. Cent. and Cooled Under Different Humidity Conditions—Megohm per square*

Cooling conditions	4 : 2 : 1 concrete			Neat cement		
	High alumina	Portland	Rapid hardening Portland	High-alumina	Portland	Rapid hardening Portland
In the desiccator	500,000	1,900	2,500	320,000	10,000	58,000
In the atmosphere	880	92	80	800	176	208
	800	80	—	—	—	—

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(To be concluded)

OIL REFINERY FILM.—The Vacuum Oil Company, Ltd., has completed a film with the title "The Story of Coryton," which traces, step by step, the transformation of a flat stretch of Essex marshland on the north bank of the Thames into a modern refinery. The film shows the preparation of the land, the erection of the various process units, flood precautions and records the opening ceremony by the Queen Mother. Copies of the 16mm film, which has a running time of thirty minutes, may be obtained from The Film Library, Sound Services, Ltd., 269, Kingston Road, Merton Park, London, S.W.19.

Theory of Plasticity: A Survey of Recent Achievements

By DR. WILLIAM PRAGER, Mem. A.S.M.E.*

No. I

In the James Clayton Lecture, delivered before the Institution of Mechanical Engineers last Friday, January 14th, and printed in part here, the author started with a brief historical introduction and then surveyed recent achievements in the theory of plasticity with emphasis on applications in mechanical engineering. In the following sections the fundamental theorems of limit analysis are discussed and their application to two and three-dimensional problems is illustrated by examples. Shakedown analysis and limit design are defined. Problems involving large plastic deformations are discussed with special reference to metal forming processes. Applications of the theory of plasticity to impact testing and blast damage are reviewed. Recent changes in the theory of structural stability in the plastic range are mentioned. Throughout the lecture, impending developments of the theory of plasticity are indicated.

Limit Analysis and Design

It is well known that elastic analysis of an indeterminate structure made of a ductile material does not yield a realistic estimate of the load-carrying capacity. Consider, for instance, the built-in beam in Fig. 1*b*, and assume that the relation between the bending moment M and the curvature κ of this beam is as shown in Fig. 1*a*. Elastic analysis shows that the absolute value of the bending moment reaches the limit M_0 first at the left-hand end of the beam when the load has the intensity $Q_1=2{\cdot}25\,M_0/a$. Since the beam bends freely when the bending moment has the absolute value M_0, a "plastic hinge" then forms at the left-hand end of the beam, and any further increase of the load is carried by the structure shown in Fig. 1*c*. Elastic analysis of this structure and superposition of its bending moments on those of the original beam under the load Q_1 show that the limiting moment M_0 is next reached at the loaded cross-section when the load has the intensity $Q_2=2{\cdot}89\,M_0/a$. Further increases of the load are carried by the statically determinate beam of Fig. 1*d*, which has a hinge at the loaded cross-section. It is found that the absolute value of the bending moment reaches the limit M_0 at the right-hand end of the beam when the load has the intensity $Q_3=3{\cdot}00\,M_0/a$. A further increase in the load would have to be carried by the structure shown in Fig. 1*e*, but this structure develops load-carrying capacity only as it is allowed to deflect in the manner indicated in Fig. 1*f*. Unless appreciable deflections are admitted, the load-carrying capacity of the original beam is therefore given by Q_3.

This simple example brings out two important facts. First, the load-carrying capacity Q_3 exceeds the elastic limit Q_1 by about 33 per cent. For a statically determinate beam, on the other hand, load-carrying capacity and elastic limit coincide. Indeterminate structures made of ductile materials therefore possess a considerable reserve of strength beyond the elastic limit, and this reserve should not be ignored by the designer. Secondly, for beams and frames with the bending moment-curvature relation in Fig. 1*a*, the load-carrying capacity can be determined by analysing a sequence of elastic structures of decreasing degrees of redundancy. This approach, however, is likely to be cumbersome for all but the simplest structures, and methods are needed that furnish the load-carrying capacity in a more direct manner.

Limit analysis is concerned with the development and application of such methods. Kazinczy (1914) and Kist (1917) were the first to stress the practical importance of "plastic analysis" of steel structures. For many years theoretical and experimental work in this field was restricted to continuous beams; Van Den Broek's book (1948) gives a good account of this phase. During recent years the splendid work of Professor Baker (1949b) and his collaborators in Cambridge has contributed much towards the general acceptance of plastic analysis by structural engineers. Further experimental work has been reported by Johnston and his collaborators (Yang, Beedle, and Johnston, 1951) in the United States and Massonet (1953) in Belgium. While this work is concerned with continuous beams and plane frames, limit analysis of space frames has been explored by Heyman (1951a) and limit analysis of arches and rings by Henderson (1952), Onat and Prager (1953), and Hwang (1953).

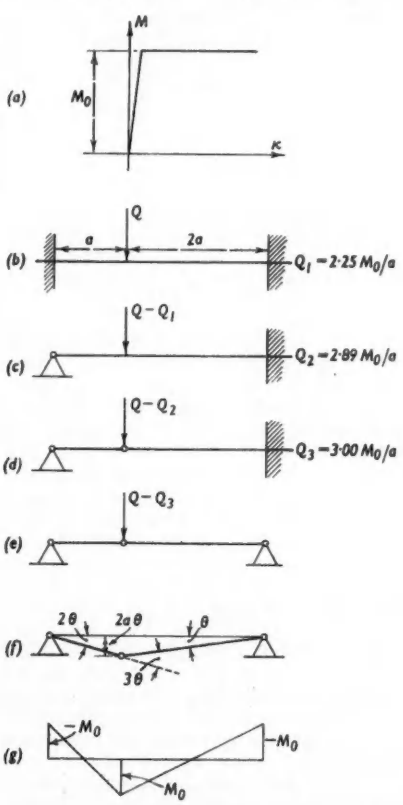

Fig. 1—Limit analysis of a statically indeterminate beam

Before considering applications of limit analysis in mechanical engineering, let us discuss two methods suggested by the structural example in Fig. 1. The first is concerned with the bending moments caused by the "critical load" Q_3. Since yield hinges will obviously develop at each end of the beam and under the load, the bending moment diagram must have the form shown in Fig. 1*g*, the bending moment having the absolute value M_0 at each yield hinge. The shear forces to the left and right of the load are found from the slopes of this diagram, and the jump in shear force at the point of application of the load gives the critical load intensity.

The second method is concerned with the mechanical energy dissipated in the incipient plastic flow. For the small plastic deformation shown in Fig. 1*f* the total energy dissipated in the three yield hinges equals $6M_0\theta$ and the work done by the load is $2a\theta Q_3$. The critical load is found by equating the dissipated energy to the work done and solving for Q_3.

In this example there could be no doubts regarding the arrangement of the yield hinges. How are we to proceed when this arrangement is not known? Greenberg and Prager (1951) have shown that, with any hypothetical arrangement of yield hinges, the first method furnishes a load intensity that cannot be larger than the critical intensity, whereas the second method gives an intensity that cannot be smaller than it. The results obtained by applying the two methods to a hypothetical arrangement of yield hinges therefore bound the critical load from below and above. The experienced analyst will often succeed in the first try to make the gap between these bounds sufficiently small for practical purposes; methods of narrowing this gap in a systematic fashion have been given by Neal and Symonds (1950a).

This technique of bounding the critical load intensity is by no means restricted to beams and frames. Its extension to perfectly plastic bodies of arbitrary shape under general conditions of loading and support constitutes one of the major advances made in the theory of plasticity during recent years. The first step was made by Drucker, Greenberg and Prager (1951); considering an elastic, perfectly plastic body subjected to gradually increasing loads, they defined as critical the load intensity at which deformation could first take place under constant loads. For the sake of mathematical simplicity, they had to assume that, up to the critical load intensity, the influence of the deformation on the equilibrium conditions could be neglected as in the theory of elasticity. An alternative approach was pointed out by Hill (1951), who considered a rigid, perfectly plastic body and defined as critical the load intensity at which the first deformation occurred. He also showed that the bounding technique of Drucker, Greenberg and Prager could be based on the extremum principles of Hill (1948b) and Markov (1947), provided that these were extended to include partially plastic bodies. A general theory of limit analysis, using the concept of the generalised plastic potential and applying to perfectly plastic continua of one, two and three dimensions, was given by Prager (1952). Recent work is concerned with the load-carrying capacity of solid bars in combined bending and twisting (Hill and Siebel, 1953), helical springs of small pitch (Freiberger, 1953), perforated sheets in plane stress (Weiss, Hodge and Prager, 1952, and others), circular plates (Pell and Prager, 1951, and others), and shells of revolution (Drucker, 1953, and others).

Bounds for the critical load intensity are obtained from the following principles:—

(1) The given loads are below the critical

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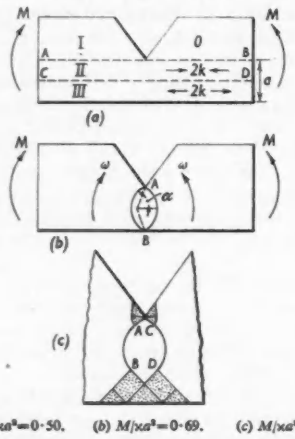
intensity if a stress field can be found that is in equilibrium with these loads and does nowhere reach the yield limit.

(2) The given loads are above the critical intensity if a velocity field can be found for which the rate of work of these loads exceeds the rate of internal energy dissipation.

The rate of internal energy dissipation used in the second principle is obtained as follows. The strain rate, found from the



(a) $M/ka^2=0\cdot50$. (b) $M/ka^2=0\cdot69$. (c) $M/ka^2=0\cdot63$.

Fig. 2—Limit analysis applied to the flexure of a notched bar in plane flow (after Green, 1953)

space derivatives of the velocity components, specifies the local rate of energy dissipation ; this is then integrated over the volume of the body.

In the application of these principles, discontinuous stress and velocity fields prove very useful. Fig. 2 shows a simple example which is due to Green (1953): a notched bar is bent by couples M applied at the ends. The bar is supposed to be very wide in the direction normal to the plane of the figure, so that it bends in plane strain. The yield condition of von Mises then agrees with that of Tresca and requires yielding under constant maximum shearing stress. Fig. 2*a* shows a discontinuous stress field. The horizontal planes AB and CD divide the bar into three layers ; the top layer I extends to the bottom of the notch, and the thickness of each of the layers II and III is one-half of the minimum thickness a of the bar. Layer I is stress free, layer II is under a longitudinal compressive stress of the intensity $2k$, where k is the yield stress in simple shear, and layer III is under a longitudinal tensile stress of the intensity $2k$. The bending moment resulting from these stresses is $0\cdot50ka^2$, and

Fig. 3—Etched cross section of mild steel specimen corresponding to Fig. 2*c* (after Green, 1953)

our first principle shows that this is a lower bound for the critical intensity of the bending couples M.

Fig. 2*b* indicates a discontinuous velocity field : the two circular arcs connecting the points A and B bound a central stationary pivot on which each half of the bar rotates with the angular velocity ω. The deformation consists in shearing along these arcs. If the length of one arc is denoted by l and the radius by r, the rate of internal energy dissipation is given by $2klr\omega$, and the rate of work of the applied couples is $2M\omega$. According to the second principle of limit analysis $M=klr$ is therefore an upper bound for the critical load intensity. By choosing the central angle 2α of the circular arcs so as to make this upper bound as small as possible, we find that the critical load intensity cannot exceed $0\cdot69ka^2$.

For some purposes the bounds $0\cdot50 \leqslant M/(ka^2) \leqslant 0\cdot69$ obtained from this simple analysis may be sufficiently close. If closer bounds are desired, more realistic stress and velocity fields must be constructed. In problems of plane strain such fields are furnished by the theory of the slip line field. Fig. 2*c* shows the enlarged central portion of the bar with the slip line field described by Green (1953). The circular arcs AB and CD are lines of localised plastic deformation similar to the circular arcs in Fig. 2*b*, and the shaded areas are regions of diffuse plastic

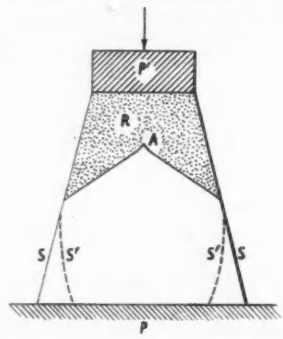


Fig. 4—Extension of stress field into rigid region (after Bishop, 1953)

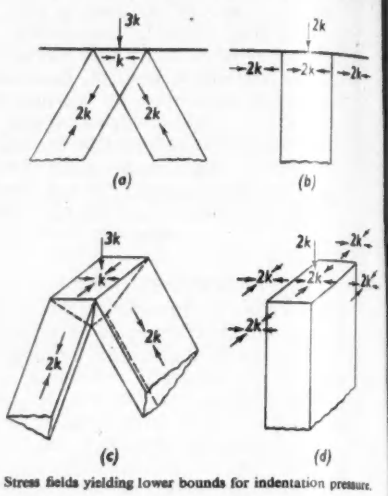
flow. The velocity field associated with this slip line field gives the upper bound $0\cdot63ka^2$ for the critical load intensity.

With the slip line field of Fig. 2*c* there is associated a stress field that satisfies the equations of equilibrium and the yield condition throughout the regions of plastic flow. If this stress field can be extended throughout the rigid regions so as to satisfy the equations of equilibrium and not to exceed the yield limit, the first principle of limit analysis furnishes a lower bound for the critical load intensity that coincides with the upper bound just obtained. Unfortunately, it is not known in the present case whether the stress field can be extended in this manner, though the etched cross-section of a mild steel specimen (Fig. 3) shows regions of plastic deformation that agree qualitatively with the considered slip line field.†

The last remark points out a serious gap in the theory of the slip line field. For the vast majority of slip line " solutions " it still remains to be shown that the stress fields of the plastic regions can be properly extended throughout the rigid regions. Such an extension must be constructed before the load intensity derived from the slip line field can be accepted as the critical load intensity. In extending the stress fields of the plastic

† The author is indebted to Dr. A. P. Green of the British Iron and Steel Research Association in Sheffield for the photograph reproduced in Fig. 3. A recent paper by Hundy (1954) contains many striking examples of agreement between slip-line field and etched specimen.

regions it usually is easier to work with states of stress at the yield limit than with states below the yield limit. As a rule the corresponding fully plastic stress fields contain lines of discontinuity. The jump conditions at such a line were established by Prager (1948b) ; the conditions at the point of intersection of straight lines of discontinuity were investigated by Winzer and Carrier (1948). Recently, Bishop (1953) gave



Stress fields yielding lower bounds for indentation pressure.

Fig. 5—Limit analysis applied to two- and three-dimensional punch indentation problems (after Shield and Drucker, 1953)

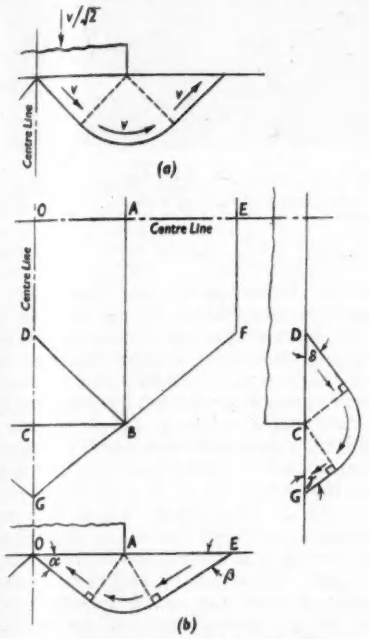
a method of continuing the stresses of a slip line field in a fully plastic manner and established important theorems concerning the critical load intensity. Fig. 4 shows a typical situation : a rigid, perfectly plastic body rests on the rigid plate P and is compressed by the punch P' under conditions of plane strain. Suppose that a slip line field and an associated velocity field have been found that are contained in the region R. The fully plastic extension of this stress field, obtained by Bishop's method, is bounded by a stress-free surface S'. If S' lies wholly inside or on the actual stress-free surface S of the given body, the slip line field gives the correct critical load intensity. If, on the other hand, S' lies wholly or in part outside S, and the velocity field in R can be extended into the region between S and S' in a manner which is compatible with the extended stress field and involves non-vanishing strain rates, the slip line field furnishes too high a value of the critical load intensity.

In Fig. 4, the point A is a re-entrant corner of the region R beyond which the given stress field is to be extended. Such corners are frequently critical in the sense that every continuation of the stress field may involve a violation of the yield condition in the neighbourhood of A. This question has been discussed by Hill (1954).

Unlike the theory of the slip-line field, the theory of limit analysis is not restricted to two-dimensional problems. Figs. 5 and 6 refer to the three-dimensional punch indentation problem discussed by Shield and Drucker (1953) : a rectangular flat punch is pressed normally against the plane surface of a semi-infinite plastic mass ; the critical pressure is to be determined at which the rigid punch begins to indent the rigid, perfectly plastic mass. Fig. 5*a* shows how a lower bound for the critical pressure can be obtained in the corresponding two-dimensional problem. The yield stress in simple shear is denoted by k, and the principal stress normal to the plane of the figure everywhere equals the arithmetic mean of the principal stresses

in this plane. The pressure on the punch is supported by two slanting legs, which are under the longitudinal compressive stress $2k$. The inclination of these legs is found from the condition that the superposition of the stresses in the legs should not lead to a violation of the yield condition in the triangle *ABC*. The stress field of Fig. 5*a* establishes $3k$ as a lower bound for the critical pressure. It is easily verified that superposition of the stress field of Fig. 5*b* on that of Fig. 5*a* does not lead to stresses in excess of the yield limit. Thus, $5k$ is a lower bound for the critical pressure.‡ Fig. 5*c* and *d* show the three-dimensional fields corresponding to the two-dimensional fields of Fig. 5*a* and *b*. The fact that the superposition of the stress fields of Fig. 5*c* and *d* does not produce stresses above the yield limit proves that $5k$ is a lower bound for the critical pressure in the three-dimensional punch indentation problem.

Fig. 6*a* shows one-half of Hill's (1949a) velocity field for the two-dimensional prob-

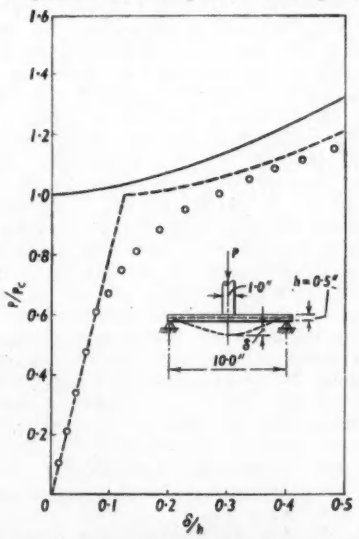


Velocity fields yielding upper bounds for indentation pressure. Square punch $p/k = 5{\cdot}35 \pm 7$ per cent.

Fig. 6—Limit analysis applied to two and three-dimensional punch indentation problems (after Shield and Drucker, 1953)

lem. This suggests the three-dimensional field indicated in Fig. 6*b*. The rectangle *OABC* in the plan view is one-quarter of the surface of contact between punch and indented material. The material in contact with the part *OABD* of this surface is supposed to move to the right in the manner shown in the section at the bottom of the figure, and the material in contact with *BCD* is assumed to move as indicated in the section at the right of the figure. By a suitable choice of the length *CD* and the angles α, β, γ and δ, the upper bound obtained from this three-dimensional velocity field is made as small as possible. For a square punch, for instance, this least upper bound is found to be $5{\cdot}71k$. The stress field of Fig. 5 and the velocity field of Fig. 6 therefore show that the critical indentation pressure for a square punch lies within ± 7 per cent of the value $5{\cdot}35k$.

A serious restriction of the usefulness of limit analysis results from the fact that the influence of the deformation on the equilibrium conditions is neglected. To discuss this difficulty, let us consider a simply supported circular plate subjected to a central transverse load *P*. According to Hopkins and Prager (see Pell and Prager, 1953), a plate of the uniform thickness h made of a rigid, perfectly plastic material with the tensile yield stress σ_0 begins to deform when the load reaches the critical intensity $P_c = \pi\sigma_0 h^2/2$, and the velocities of the incipient plastic flow correspond to the transition from the flat plate to a conical shell. Since this brings membrane forces into action, continuing plastic deformation requires increasing load. While an exact theory for this behaviour is not available, Haythornthwaite and Onat (1954) suggested an approximate analysis, which assumes that the plate continues to deform according to the velocities of the incipient plastic flow and applies the methods of limit analysis to the resulting conical shells. Fig. 7 confronts experimental results obtained by these authors with the prediction of this approximate theory. The inset in Fig. 7 gives the dimensions of the mild steel plate; the load was applied by means of a flat punch whose diameter was one-tenth the plate diameter. The full line in Fig. 7 corresponds to the approximate theory; to take account of the elastic deformations of the plate, this curve might be shifted to the position shown by the dashed line. While no marked change in mechanical behaviour occurs at the critical load P_c, the overall agreement between experiment and theory is satisfactory. This example seems to indicate that, for mild steel at least, work hardening is less important than the effect just discussed. While the change of shape caused by plastic flow here led to an increase in the yield load, examples are readily found



Deformation increases critical load (after Haythornthwaite and Onat, 1954).
$P_c = \pi\sigma_0 h^2/2$.

Fig. 7—Limit analysis applied to bending of circular plate

in which this change results in a decrease in the yield load. The development of a general theory of these effects will greatly advance limit analysis. A first step towards such a theory has been made by Onat (1953).

Whereas limit analysis considers the effect of a single application of load, shakedown analysis is concerned with the mechanical behaviour of an elastic, plastic body subjected to loads that vary independently between given minimum and maximum values. As was first shown by Horne (1949), two types of failure are possible in the second case, even though no single possible combination of the loads can produce the type of failure that is considered in limit analysis. As the loads continue to vary in a certain sequence between the given extreme values, cycles of plastic flow may occur, and these cycles will be repeated as often as the sequence of loads is repeated. Alternatively, intermittent plastic flow without reversal of the sense of deformation may occur and continue as long as the load sequences are continued. To date, most work on shakedown analysis has been concerned with structural applications (Bleich, 1932; Melan, 1936; Neal and Symonds, 1950b). The general shakedown problem of the three-dimensional elastic, plastic continuum was discussed by Melan (1938) and Symonds (1951).

The understanding of the general principles of limit and shakedown analysis has been considerably advanced by various graphical representations of the mechanical behaviour of simple elastic, plastic structures under various conditions of loading (Prager, 1948c; Rzhanitzin, 1949; Finzi, 1952; Hodge, 1954).

In structural engineering, limit analysis is concerned with estimating the load-carrying capacity of a given structure. Limit design, on the other hand, is concerned with economically allocating yield strength to the members of a structure in such a manner that given loads will not exceed its load-carrying capacity. While the theory of limit design is not as well developed as that of limit analysis, limit design of continuous beams and frames has been discussed in recent years (Baker, 1949a; Heyman, 1951b; Foulkes, 1953; Prager, 1953b). The corresponding field of shakedown design is virtually unexplored.

(To be continued)

Roof Bolting Demonstration

LAST week, demonstrations of dustless drilling and roof bolting were given by Holman Brothers, Ltd., of Camborne, under working conditions at the gypsum mines at Mountfield, Robertsbridge, Sussex. The "Dryductor" drills (see THE ENGINEER, May 11, 1951) made by the firm were demonstrated in operation with the double telescopic "Airleg" and "Stoperleg" mountings, and the firm's impact wrench was used for fastening roof bolts.

Considerable interest is at present being shown in roof bolting, as a method of support in mining and tunnelling. This system has been extensively used for a number of years in the United States, and is now being applied in this country. Briefly, it involves inserting steel rods in the roof of a tunnel or mine, anchoring them at their inner ends by some form of wedge grip, and supporting the rock face at their outer ends by a steel plate fastened to the bolt, or by beams fastened between two bolts. Thus the roof is supported from anchor points in a relatively unstressed zone some distance in from the actual excavation. Bolts at least 1in in diameter and of lengths of 3ft or upwards are generally used, and there are various wedging devices to expand the inner end and provide a positive anchorage. At the demonstration, two 3ft bolts were fixed in the roof and a timber beam positioned between them in under three minutes. First, the two holes were drilled, using the "Stoperleg" support for the drill. The "Dryductor" system was shown to advantage here, all dust and sludge from the drilling being evacuated by the drill so that none dropped down on the operator. To insert the bolt in the hole a driving head was fastened in the chuck of the drill, and the bolt was speedily driven in. Then the timber beam, which had already been drilled with appropriate holes, was inserted over the bolts, two steel gripping plates were added, and the two nuts were tightened to a given torque by an impact wrench. During the course of the demonstration bolts were fixed in the floor of the working, and in the side wall, using the "Airleg" mounting.

‡ In the two-dimensional case, coincident bounds for the critical pressure can be obtained which show this pressure to equal $(2+\pi)k$.

Atomic Energy in 1954

TO the engineer the encouraging trend of the year under review was the steady progress reported in the development of various forms of reactors which aim at the production of power for civil purposes, though it must be admitted that the year's most striking event, of any made public, was the report of an alternative way of producing hydrogen bombs. Only a few years ago leading scientific opinion seemed to be that in any thermo-nuclear reaction making use of hydrogen an exceedingly high temperature would be required, measured indeed in millions of degrees, and that the one way of achieving this seemed to be the employment of a uranium bomb as detonator. In the years since it has been generally understood that this was the method normally used; requiring, of course, that every hydrogen bomb must needs be at least as large as the smallest uranium bomb that can be made. The question whether this is still the case is raised by the account of "The Making of the H. Bomb," which appeared during the year in the magazine *Time* and was abstracted at some length in the *American Bulletin of Atomic Scientists* (June, 1954) and in the *British Atomic Scientists' Journal* (July, 1954). According to this there now exist two categories of H. bombs, a "wet" and a "dry." The "wet" is so called because it makes use of liquefied hydrogen isotopes, elaborately cooled and kept under pressure. The "dry" variety uses instead a solid compound, lithium hydride, and is transportable by air, which the "wet" by reason of its weight could hardly be (the weight, with its equipment, being estimated as no less than 65 tons apiece). It is suggested that the device exploded on Eniwetok in 1952 was "wet" and what was perhaps the first "dry" one in 1954. Whether this alternative was first discovered in U.S.A., U.S.S.R. or elsewhere is by no means clear; but it does now seem that manufacture may be by means of either of these processes.

It is always hard to know what truth there is in claims made for or by the Soviet Union; for example, that the first industrial power station to be run on atomic energy began power production (5000kW) in U.S.S.R. in June last, and generated electricity for the use of industry and agriculture in its district. It is claimed also that work is in hand on the construction of reactors of 50,000kW to 100,000kW. The Western Powers, especially U.S.A. and Britain, are naturally desirous that leadership in the exploitation of the peaceful possibilities of nuclear power should not pass to other Powers, including the U.S.S.R. Great activity has lately been shown by the American Atomic Energy Commission, which has placed a specially interesting contract with the Westinghouse Electric Corporation for a full-scale atomic electricity plant, to cost some 30,000,000 dollars and produce 60,000kW or more of electric energy, together with a certain amount of plutonium.

U.S. Atomic Energy Commission Report

In our issue of April 16th last we reviewed the fifteenth biannual report to Congress of the U.S. Atomic Energy Commission. It recorded that by the close of 1953 the American capital investment in atomic energy plant had risen to some 5000 million dollars, and that the average rate of expenditure for further plant and equipment was at the rate of 100 million dollars a month. The probable cost per kilowatt installed in current plans for atomic power plants is hard to come by, but figures put forward by certain of the groups of industrial firms concerned indicate that power should be producible at an overall cost comparable with the prices ruling in stations making use of coal, oil or gas as the basic fuel. In this survey four types of reactors were concerned, viz. that using pressurised water as moderator and coolant, the sodium with graphite alternative, the fast breeder and the homogeneous reactor. The first of them interested particularly the Westinghouse Electric Corporation, and is thought to represent a major advance towards a civilian reactor, the power, as already stated, being of the order of 60MW and the time for building three or four years. Apart from this particular contract, the number of industrial firms which hold American Government orders for nuclear reactors of one kind or another appears to grow steadily; it now includes such firms as Boeing, Convair, Lockheed, Martin, North American, Pratt and Whitney, General Electric and Fairchild. Press reports add that 10,000,000 dollars have been allocated for a new Lockheed laboratory to link the nuclear energy and guided missile fields of investigation.

The Argonne National Laboratory is working on a breeder reactor scheme which aims at the production, during normal operation as a power producer, of at least as much fissile material as it consumes; for this important development a fast reaction with enriched fuel is preferable, but care needs to be taken to ensure that the reaction shall not become so rapid as to get out of hand. The homogeneous reactor is a bold experiment with a 1000kW heat output; its leading feature is the use of a single mixture to act both as fuel and moderator. The merits claimed for it are stated to be the elimination of fuel fabrication, its chemical simplicity and easy construction. In addition to these developments, work has continued on the possible recovery of useful fuel from radioactive waste products, and on the best means for the disposal of such products as are not usable in any known way; success is reported in the endeavour to recover uranium 235 from enriched reactor fuel already partly "burned." The first university owned nuclear pile built in America has as its main objective the instruction of students, both undergraduate and post-graduate; this is at the University of North Carolina and now at work.

Much interest has naturally been created by the novel issue by an industrial firm (North American Aviation) of the first "atomic pile catalogue." This describes the types of reactor which it is prepared to build for approved clients. The three designs offered are the so-called "water boiler" with a core of enriched uranium sulphate solution and graphite reflector; the pool reactor in which the core may be enriched U.235 with some aluminium alloy and be immersed in a pool of water to serve as moderator, coolant and shield; and the homogeneous reactor with a mixed core of graphite and enriched uranium.

We gave a summary in our issue of October 15th of the more important points in the succeeding U.S.A.E.C. half-yearly report (the sixteenth) for the second half of the period. Its most striking feature was the substantial growth revealed in the production in the U.S.A. of uranium ore and concentrates. By May, 1954, some 430 mining operators were delivering ore from 530 mines, the Colorado Plateau being the most productive area. As regards the richness of such deposits it is disclosed that at least fifteen have not less than 100,000 tons of ore and some much exceed this figure. It is no simple matter to make any reliable comparison between these figures and those for the rest of the world. The countries on the other side of the "Iron Curtain" are little disposed to be communicative, but in his presidential address to the Institution of Electrical Engineers, Mr. Eccles was able to give, on American authority, the following assessment of the world reserves of all forms of fuel, including both uranium and thorium:

Fuel	World reserves	Source of data	Total energy, B.Th.U.
Crude oil	610×10^9 barrels	Weeks and Moulten ...	$X10^{20}$ 3·5
Natural gasoline	$11 \cdot 5 \times 10^9$ barrels	American Petroleum Institute	0·07
Shale oil	620×10^9 barrels	Bureau of Mines	4
Natural gas ...	560×10^{12} cubic feet	American Gas Association	0·6
Coal	3482×10^9 tons	Bureau of Mines	72·2
Total conventional fuel	—	—	80
Uranium	25×10^6 tons	Raw Materials Division of A.E.C.	1700 at 1 : 1 breeding 71
Thorium	1×10^6 tons	Raw Materials Division of A.E.C.	
Total new fuel ...	—	—	1800

As Mr. Eccles points out, these figures suggest that the world reserves of crude oil are but 5 per cent of the coal reserves, whilst (assuming successful breeder reactors) the potential energy of atomic fuel is twenty times as great as all the rest put together. So it seems that if the supply of fossil fuels is not likely to last more than a few hundreds of years, that of the atomic fuels may suffice for some thousands!

The U.S.A.E.C. reports that its unit cost of production in the first six months of the year proved to be lower than in the previous half year. Also that by proper processing, natural uranium fuel that has already been used in a reactor can now be enriched from diffusion plants so as to be again available for reactor use.

In a special report to Congress the Commission gives a five-year programme of industrial nuclear power development. It provides for five separate approaches: (1) pressurised water reactor to be completed in 1957; (2) boiling water reactor due in 1956; (3) sodium graphite reactor in 1955; (4) homogeneous reactor by 1956–58; and (5) a fast breeder by 1958; the whole to cost about 200 million dollars. It was once thought that any actual boiling within the core of a water-cooled reactor might lead to instability in operation, but experiments at the Argonne Laboratory appear to show that this is not the case. Indeed, it is considered that boiling water reactors may be designed so as to be self-regulating, shutting themselves off when trouble threatens. It is planned to construct an experimental reactor of this type to produce 5000kW of electric power by the winter of 1956; this will use both normal and enriched uranium as fuel.

British Atomic Energy Establishments

In a lecture given early in the year by Sir John Cockcroft under the auspices of the British Atomic Scientists' Association, it was emphasised that the Atomic Energy Research Establishment, under his direction at Harwell, was responsible for research into all problems

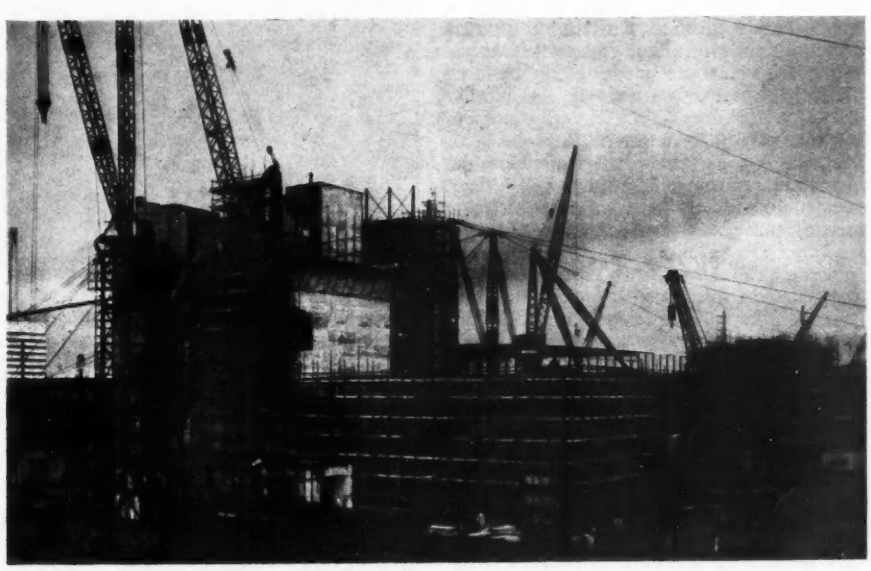
Calder Hall power station. One of the two nuclear reactors is shown here under construction. In the foreground is part of the reactor vessel fabricated and ready to be lifted into position

of atomic energy (except those concerned solely with atomic weapons, which come under Sir William Penney at Aldermaston). He said also that during the past two years Harwell had aimed especially at the development of nuclear power for civil purposes and that this would continue as one of its chief objectives. Although ordinary water is useful as a moderator, and is, of course, a cheap material to use, it suffers from the disadvantage that it requires enriched uranium to be used. The fuel cost therefore tends to be high and it is not yet known whether it is most economical to moderate a power reactor with light or heavy water. The first nuclear power unit in Britain (being built in Cumberland), is expected to be ready in two years' time, and to use the familiar graphite as moderator and carbon dioxide as the heat transfer medium ; this choice was made after a close study in collaboration with industry and the British Electricity Authority.

Harwell's chemistry and isotope divisions have been looking into the troublesome problem of whether some good use can be made of the radioactive products of uranium fission, and it is found that some of them may greatly increase industrial output in the polymerising of ethylene to polyethylene, and that others can be used to improve the properties of certain plastics. The industrial objectives at which these Establishments aim were set out in Cockcroft's address to the Oxford meeting of the British Association. Factors to be taken into account, if the goal of economical nuclear power production is to be attained, are that the reactor must burn a large enough proportion of the uranium to achieve low fuel costs, that the fuel must have been processed by the most economical means and have chemical and metallurgical features favourable to a long life for the reactor, and that, besides ensuring the recovery of any valuable products such as plutonium, the reactor must be so designed as to be reliable in action, safe in handling and not too expensive to build.

These Establishments comprise the main laboratory at Harwell with its radiochemical centre at Amersham, and those concerned with fissile material production at Risley (planning and administration), Springfields (ore processing), Sellafield (plutonium), Capenhurst (diffusion plants), and Aldermaston (weapons). Typical views of the Calder Hall power station and Capenhurst works are reproduced on these pages. All were formerly controlled by the Ministry of Supply, but are now (including the power stations at Calder Hall and Dounreay) under the wing of the new Atomic Energy Authority set up by Act of Parliament a few months ago. Under this scheme the Lord President of the Council is responsible to Parliament for general policy and finance (though the Ministry of Supply continues responsible for all atomic weapons for the Services) and can contract with the Atomic Energy Authority (A.E.A.) for the production of the nuclear components of weapons and the necessary research work relating thereto. This sounds somewhat complicated, but it provides that the A.E.A. shall be free to carry out experimental investigations on the forms of warhead proposed for use. The A.E.A. has a full-time chairman, Sir Edwin Plowden and eight members (some full-time and some part-time). These include Sir John Cockcroft, Sir Christopher Hinton, Sir William Penney, Lord Cherwell, Sir Luke Fawcett, Sir Ivan Stedaford, and Sir Donald Perrott. The estimated expenditure for the current financial year is given as £54,000,000, half of which is for new plant and buildings. This figure, however, covers only the civil work, since the cost of weapon research and production will be borne on the Ministry of Supply vote as heretofore. The Atomic Energy Authority Act (which received the Royal Assent on June 4th) does not aim at the creation of any nationalised industry ; indeed, the intention is that private industry should be encouraged to play as large a part as possible. The Act does, however, include power for the A.E.A. to provide technical training, to place research contracts with university and industrial laboratories, and to make grants to encourage independent production and the use of atomic energy for civil work. The new power plant under construction in Cumberland is to be owned and run by the A.E.A., which will sell the power produced to the British Electricity Authority—at some such figure, it is estimated, as a penny a unit for generating costs. Once industry enters this new field with vigour it seems hardly likely, to quote a bold forecast in *The Economist* (July 31st last) that it can fail to discover a shorter way of harnessing the power of the atom than by using it to boil water to make steam to drive electric generators !

The largest of the British reactors so far built are at Harwell. Of these the first—built in 1948—was the British experimental pile (BEPO), a graphite-moderated, air-cooled reactor intended to provide information for the design of larger plants in the future. The latest is a pile using heavy water as moderator and known as " Dimple " (deuterium moderated pile, low energy) ; the heavy water, in which the fuel is submerged, is contained in a tank surrounded



Calder Hall power station. On the left is No. 1 reactor under construction. An end of one of its heat exchangers can be seen lying on its side prior to erection. No. 2 reactor is in the background, right ; and the turbine house framework is between the two reactors

Capenhurst works. One of the many instrument and control decks of the diffusion plant. The main plant including compressors, motors, coolers and diffusion filters, is housed below the level shown

by a graphite reflector, and outside this the usual concrete radiation shield. As this plant will only be used at a low power it is not expected to be so radioactive as to hinder appreciably the amount of handling needed in research work. It is indeed reassuring to know that so slight is the degree of radiation injury caused to the staff employed at Harwell that risk to life and health arises more from falling down holes, getting splinters into eyes, and, most of all, from accidents on the main road outside the Establishment !

There has been opened a reactor school at Harwell to encourage industrial firms to take a greater share in the future of nuclear power. It provides a three months' course for members of their staffs to learn the essential features of this new technology. Three courses will be held each year, starting in September, January and May. About twenty-five students can be accommodated at a time. If Cockcroft's estimate that the period of growing industrial development in this field may be put at some eight years, it should be possible to build power units adequate to save some 20,000,000 tons of coal a year between 1965 and 1970, or earlier still, if the need pressed.

It is interesting to learn from its annual report to March last that the British Electricity Authority has set up a special engineering section to plan future nuclear power stations for its own use. It hopes within a few years to undertake the building of such stations, as part of its normal work, to produce electricity competitive in price with that produced from coal. If this forecast is realised it will have an important bearing on the otherwise difficult problem of finding a coal supply adequate to our future power requirements.

Some Military Features

As already mentioned a striking advance is indicated in the development of thermo-nuclear bombs ; these it seems may now be made by a " wet " or a " dry " process. The " wet " was first employed by the U.S.A. Government and, it is thought, copied in U.S.S.R. as an outcome of information supplied by various refugee " agents." The new " dry " process of manufacture makes use of a solid compound and leads to a much more compact bomb with at least equal explosive power. It may perhaps have been used in the Russian experiments of August, 1953. It might be thought that this more compact design would open the way to the tactical use of hydrogen bombs for defence against aggressive action by large armies ; but this is hardly likely to be so since it seems that the tactical form of the uranium war head provides as powerful a shell as the military could use, and anything further in this direction has the disadvantage of " over-killing." If as is hoped the " mass-bombing " of civilians can now be regarded as ruled out for future wars, the hydrogen bomb can hardly prove an efficient military weapon ; and it has, at any rate at present, no known adaptability for conversion into a source of power for civilian purposes.

The uranium war head, on the other hand, can be constructed as a tactical weapon for field use, is not much beyond the best efficiency limit in size, and is suitable for strategic use in attacks on fuel or transport depots, oil refineries, ammunition stores, railway junctions and like targets. It is, therefore, a welcome addition to " conventional weapons " for it strengthens the defensive power of the West and lessens the threat of attack by powers holding huge masses of manpower at their ready disposal.

Capenhurst works. The two storage spheres shown here hold a buffer stock of nitrogen for feeding to the main stages of the diffusion plant

It was announced during the year that as part of U.S. developments, a fifth battalion of the 280mm " atomic cannon " had been sent to West Germany, and that firing for training purposes (using conventional shells) took place in April. It was added that an atomic shell, if used, would have had nearly as much explosive power as the bombs used against Japan in 1945.

A disturbing feature of the situation must be admitted, however : if another megalomaniac like Hitler should ever seize power, in any country, he might when " cornered " seek to destroy everything he could reach, before being himself destroyed, and to use if he could the hydrogen bomb for the purpose—employing no doubt the most " aggressive " form of casing for the bomb that he could obtain, say the use of cobalt or like material, which on being bombarded by neutrons gives off exceedingly powerful gamma rays and is poisonous to life on a vast scale. Sir George Thomson has put this point (as reported in the U.S. Press) very forcefully : " To use the cobalt bomb as a weapon would be crazy—though it might be a form of suicide ! "

Numerous statements have appeared in the Press as to some of the hazards to life caused by the American hydrogen bomb tests near Bikini in the earlier part of the year. The sufferers were stated to be the crews of certain Japanese fishing craft operating in that part of the Pacific Ocean. It appears that owing to the uncertainties in weather prediction it is not easy to define which areas are safe, and which are not, to the exposed crews of small vessels. The power of the bomb used in this experimental work was considerable, and is stated to have been equivalent to 14,000,000 tons of T.N.T. It is not only in the neighbourhood of Bikini that these things happen. In June last it was reported that thirty-six hours after the detonation of an atom bomb at the Nevada proving ground in U.S.A. a rainstorm near New York, over 2000 miles away, produced a high, even if not hazardous, fall of radioactive material. And some experiments in U.S.S.R. have lately shown a similar effect.

Dr. Adrian in his presidential address to the B.A. meeting at Oxford in September, stressed the fact that scientific discoveries as a whole cannot avoid advancing "methods of warfare"; this they do for instance, when armies are made more healthy just as much as when they increase the striking power of their weapons. On the other hand, even peacetime experiment, if on a very large scale, can also carry its dangers. Repeated atomic explosions may lead to " a degree of general radioactivity which no one can tolerate or escape." And that the human race cannot stand more than a few thousand large atomic explosions—whether these hit their target or miss it !

Mobile Power Units

At first sight aircraft might seem to be the most likely candidates for the use of the light nuclear fuel. But this would first require the discovery of some far lighter biological shield for the crew than layers of lead or concrete : until such a form of shielding material is available advantage cannot be taken of the exceedingly light weight of nuclear fuel. Never-

theless, it is reported that a laboratory is planned to be built in U.S.A., costing some 30,000,000 dollars, with the specific object of aiding the development of an "atomic aero-engine," and that the U.S.A.F. and the Pratt and Whitney firms are jointly concerned in a venture in which it is hoped to develop a jet engine having a thrust of no less than 25,000 lb. Other reports tell of efforts of the same sort undertaken elsewhere, notably by The General Electric and Vultee firms.

Mobile power units making use of nuclear energy naturally have a much readier application for sea-going vessels (including submarines), or large vehicles for use on the road. But, however promising this may be, and whatever may be reported, there can be little doubt that the soundest line of approach is by first learning how to build really satisfactory stationary power reactors ; here the field is so extensive and the number of possible lines of approach so great that some years of work are likely to be needed to find the most efficient and economical units for the purpose. By then other more adventurous undertakings will have a far better chance of success. Much energy has been shown in the U.S.A. in various efforts to build nuclear engines for use in submarines. One of these was made by the Westinghouse Company and it is interesting to learn the view expressed by the manager of their Atomic Power Division on the great difficulty of the task : "It was the toughest job we ever took on — harder by far than jet engine research, for example— and we could not even have attempted to do it all by ourselves. . . . However, we are told that our reactor project has progressed more smoothly than any other in the post-war period. If this is so, we would dislike taking part in one which did not go smoothly."

Fundamental Research

At the end of the second world war nuclear physicists were glad to return from war service to their laboratories to investigate fundamental principles and, in some cases, their possible application to civil purposes. Sir John Cockcroft remarked in an address to the physics section of the British Association: "they returned with new electronic techniques born of radar experience and a competence in machine building. Partly, no doubt, as a result of this skill and enterprise there is now a 330-million-volt electric synchrotron at Glasgow, a 400-million apparatus in Liverpool, and a 1000-million one in Birmingham. In America one plant with an energy of no less than 6000 million is at work, and the new international one for Geneva will be even larger. What the result of all this immense research effort may be it remains for the future to disclose." At the close of his address Cockcroft was bold to suggest that the energy of the fusion of light elements might yet prove to be found capable of providing a source of "power without limit"—and this before "the end of our uranium fuel reserves" !

At the first session of the Council of the European Organisation for Nuclear Research, which opened in Geneva in October last, Sir Ben Lockspeiser, of the British D.S.I.R., was elected president with a vice-president from Denmark and one from Italy ; a Swiss was chosen as the director-general and his assistant an Italian. Its laboratory, which will be erected at Megrin, near Geneva, will have the purpose of enabling Western European States to co-operate with both U.S.A. and U.S.S.R. in important fields of research. The laboratory is to have a very powerful synchro-cyclotron and a proton synchrotron with an estimated energy equivalent of no less than 25,000 million electron volts.

Radioactive isotopes are proving of great value in medical investigations not only for therapeutic treatment, but as tracer elements, in particular those having a comparatively short "half-life," since there is then less risk of the human body being overdosed by the radiation of the elements so employed. They are gradually coming to be of service also for such various technical uses as thickness gauging, density measurements, leak detectors in pipelines, and the study of friction wear. Moreover, it appears that radioactive cobalt proves to be a stronger and cheaper tool than radium itself for general use. A radio-isotope conference was held at Oxford in July last. Most of the discussion dealt with the medical and chemical uses of radio-isotopes, but there was described an ingenious method of thickness gauging in which it was found possible to measure from the outside surface of pipes the degree of corrosion present on their insides. Another industrial application concerned the study of water flow and velocity measurements and another the measurement wear in carbide-tipped cutting tools.

Sales in this country of radioactive isotopes in 1954 were estimated as likely to be no less than £600,000, of which about one-third may be exported ; the rate of production is reported to be increasing steadily.

Gas Turbines in 1954

No. II—(*Concluded from page 57, January 14th*)

Sulzer Brothers, Ltd., Winterthur

SULZER Brothers, Ltd., of Winterthur, Switzerland, is still actively developing the single-shaft gas turbine, particularly in the direction of simplification and higher efficiencies. In order not to sacrifice one of the fundamental advantages of the gas turbine, namely, its ability to do without any cooling water, the tendency has been towards layouts with compression in one single stage. Figs. 4 and 5 show such a plant in schematic form and in actual layout. The slight drop in plant efficiency entailed by the single-stage compression has been offset by the development in the company's aerodynamic laboratories of compressor and turbine blading giving a higher stage efficiency. These gas turbine sets, which can be built with power outputs ranging from approximately 1500kW to 15,000kW, can be adapted to burn either liquid or gaseous fuels. One particularly attractive application is for iron and steel works, utilising blast-furnace gas as a fuel. As this fuel has a low calorific value, relatively large quantities have to be compressed and the small independently driven pump usual with liquid fuels cannot be used. The gas in this case is compressed by a machine similar to the air compressor, and which is mechanically coupled to the main shaft. In addition to driving an alternator, these gas turbine plants can also be equipped to produce electricity and blast-furnace air simultaneously by means of an additional blast-furnace blower driven parallel with the alternator. The regulation of such an installation presented particular problems and Sulzer Brothers has developed a patented system. As is known, both the air quantity and pressure requirements of a blast-furnace are very variable and consequently the power requirements of the blast-furnace blower also vary within large limits and may for large periods at a time be in the order of half to two-thirds of the maximum requirement. This has very unfavourable repercussions when gas turbine drive is envisaged, as the part-load characteristic is the weak point of a simple single-shaft gas turbine. Reducing the load means reducing the temperature at turbine inlet with a consequently large drop in efficiency. The blast-furnace blower, on the other hand, also has a drooping efficiency curve for reduced delivery when using any of the regulating systems which are usual to-day. Taking these two facts into consideration, the system provides for a blast-furnace blower which is laid out for the normal requirements of the blast-furnace, i.e. average values for air quantity and pressure, and the gas turbine supplies power to both blower and alternator. During the times when the blast-furnace requires a larger amount of air, this is tapped from the gas turbine circuit, which entails practically no losses as the branched-off air quantity is relatively small. As the amount of combustion gas passing through the turbine will be correspondingly somewhat reduced, the power output, i.e. the electric energy produced, will drop slightly. Should the blast-furnace on the contrary require less air, then this surplus is re-expanded in a recuperation turbine which is directly coupled to the blast-furnace blower, and the power input to the alternator rises. The important aspect of this system is that for all conditions the power output of the gas turbine remains practically constant, which means that, apart from adaptability to the requirements of the blast-furnace, the efficiency remains high throughout. In Fig. 6 a parabolic pressure volume characteristic has been assumed for the blast-furnace. Working to this characteristic, three efficiency curves have been plotted : (*a*) for the regulating system of a combined gas turbine-blower plant as described above ; (*b*) for a blower laid out for the maximum wind conditions with regulation by recuperation turbine, and (*c*) for a blower corresponding to alternative (*b*), but with throttling at intake in place on the recuperation turbine.

Fig. 7 shows the relation between blast quantity and pressure on the one hand and

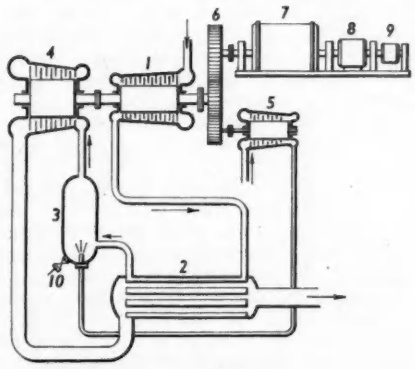


Fig. 4—Working diagram of a Sulzer single-shaft gas turbine using blast-furnace gas as a fuel

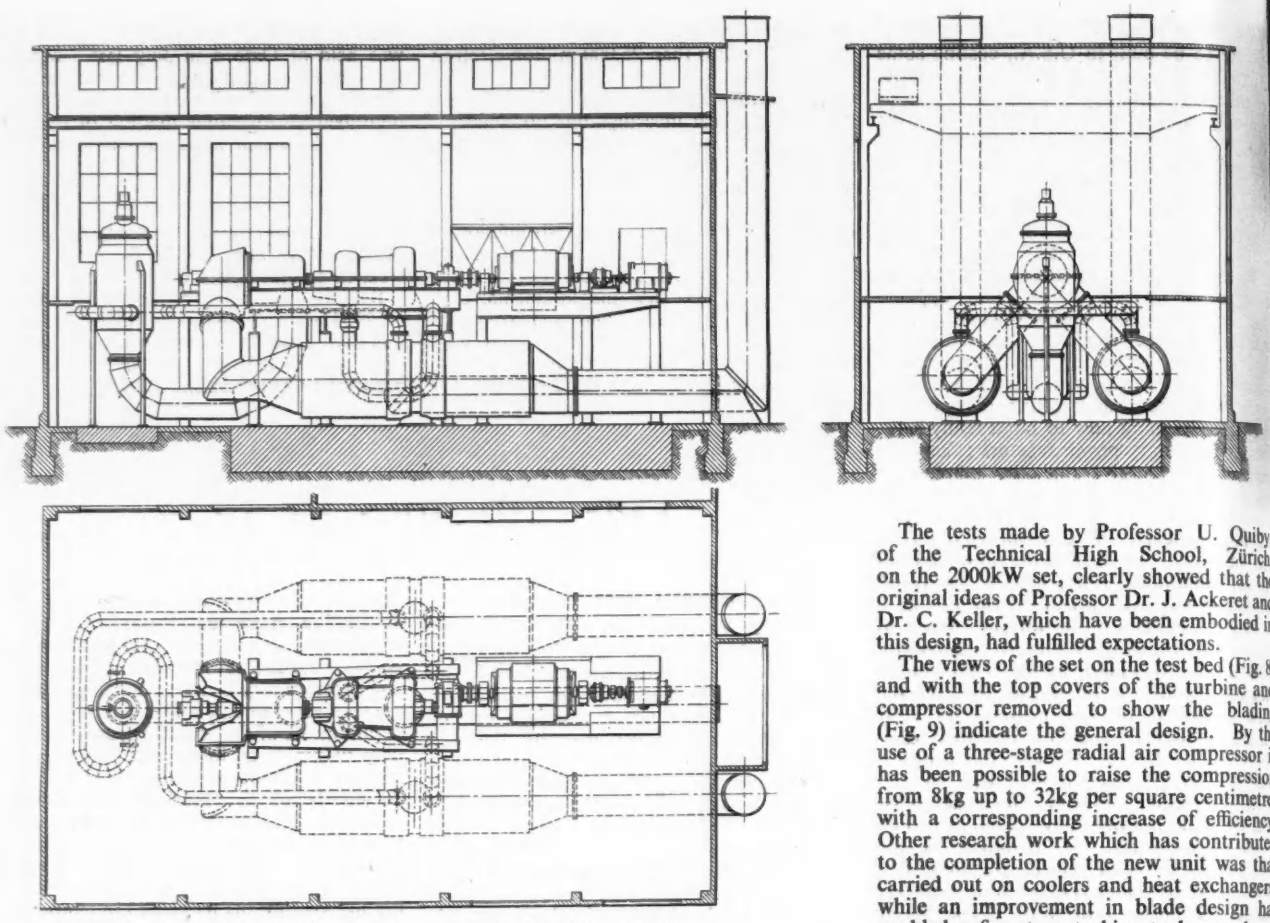
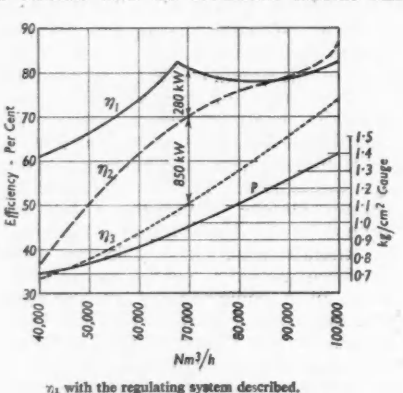


Fig. 5—General arrangement of a Sulzer gas-fired, single-shaft gas turbine

production of electrical power on the other, established for a 7500kW unit. The zone to the right of the blower characteristic curve can be obtained by tapping air from the gas turbine cycle as described above, the zone to the left means by-passing some of the air through the recuperation turbine. As can also be seen on this diagram, the efficiency remains practically constant over a large working range. In order to cater for periods when less blast-furnace gas is available than would be necessary to obtain the full power output, the combustion chamber is equipped with an additional oil burner, by which the full output is ensured.

Escher Wyss, Ltd., Zurich

It was in the course of our review of gas turbine practice in 1952 that we referred for the first time to the new design of single-shaft air turbine with the combined turbine and compressor forming one unit. We are now informed by Escher Wyss, Ltd., of Terminal House, 52, Grosvenor Gardens, London, S.W.1, that during the later months of 1954 a 2000kW oil-fired generating set, of " Tuco " or combined turbine and compressor design, was completed and underwent extensive tests at the Escher Wyss works in Zürich. This set, which we illustrate in Figs. 8 and 9, will shortly be erected in Japan at the Tsurumi Works. A second set of the same output, but arranged for firing with coal and oil, will in the early spring be completed and installed in the German Escher Wyss works at Ravensburg. A third set of 1000kW capacity is being built at Clydebank by John Brown and Co. (Clydebank), Ltd.



η_1 with the regulating system described.
η_2 with regulation by recuperation turbine.
η_3 with regulation by intake throttling

Fig. 6—Adiabatic efficiency for blast production along the pressure-volume curve P

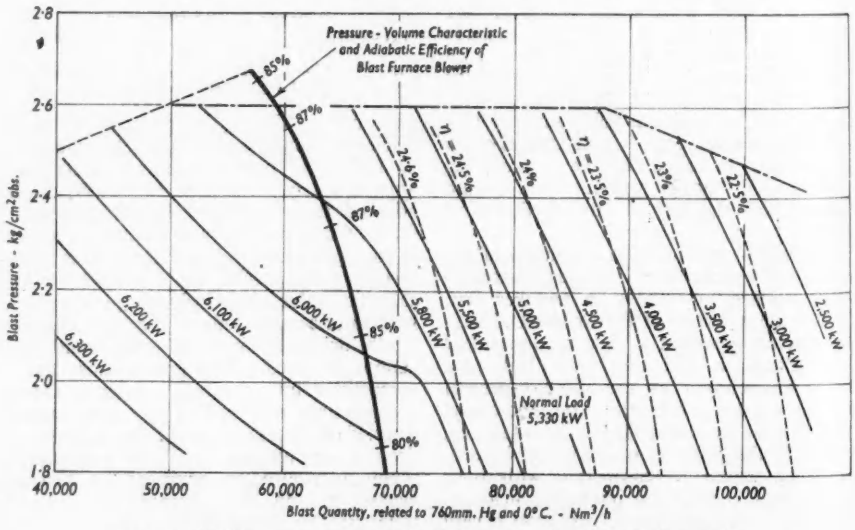


Fig. 7—Electric power output and efficiency as a function of air quantity

The tests made by Professor U. Quiby, of the Technical High School, Zürich, on the 2000kW set, clearly showed that the original ideas of Professor Dr. J. Ackeret and Dr. C. Keller, which have been embodied in this design, had fulfilled expectations.

The views of the set on the test bed (Fig. 8) and with the top covers of the turbine and compressor removed to show the blading (Fig. 9) indicate the general design. By the use of a three-stage radial air compressor it has been possible to raise the compression from 8kg up to 32kg per square centimetre, with a corresponding increase of efficiency. Other research work which has contributed to the completion of the new unit was that carried out on coolers and heat exchangers, while an improvement in blade design has enabled a five-stage turbine to be employed instead of twelve stages in the two turbines of the earlier units. The use of the newer alloy steels in the compressor has enabled the operating temperatures to be raised to practically the same as those of the air turbine without reducing reliability and with an increase of efficiency. By the use of double-wall construction the amounts of special steels required have been reduced, and these steels are now only used for rotor blading and the inner housing with its guiding blades. The space between the inner and outer casings is filled with insulating material. The inner casing is only under the pressure of the closed circuit and can be made as thin as the precision casting of steel allows.

The outer casing, which has to withstand the working pressure, is only exposed to a

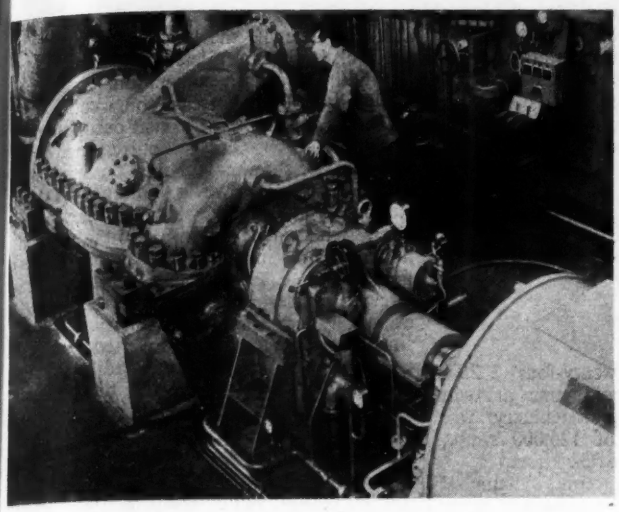


Fig. 8—2000kW "Tuco" closed circuit air turbine with combined turbine and compressor unit on test bed

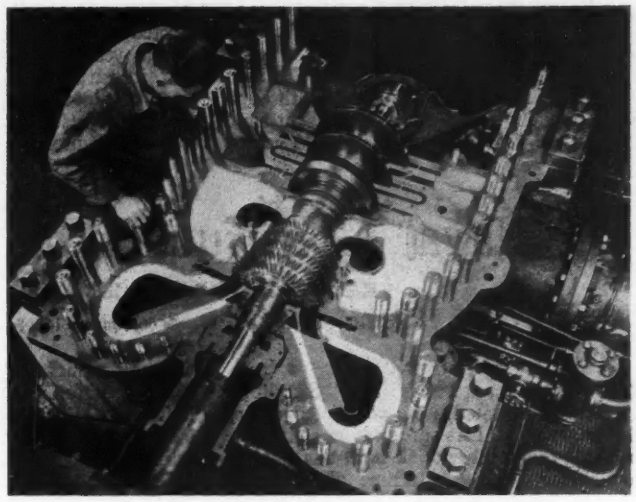


Fig. 9—2000kW "Tuco" air turbine with upper casing removed to show blading

temperature of about 100 deg. Cent., and can be constructed of ordinary cast steel. The general structure of the turbine and compressor has so been designed that practically no heat-resisting steel is needed and ordinary commercial austenitic steels can be safely used. As will be seen from the photographs, only two stuffing-boxes are needed for the whole unit, and are only under circuit pressure. These, together with only two main bearings, have given increased reliability.

The single-shaft combined turbine and compressor working on the closed circuit principle is now standardised in 2000kW, 5000kW and 10,000kW sets. In Fig. 10 we show the general arrangement of the closed circuit turbine and compressor. It will be seen that the principal parts are an air heater, a heat exchanger, and a precooler for the air before it enters the compressor. A wide range of fuels is available for firing the air heater. Arrangements have also been made to use this type of air turbine generator with a reactor to produce electrical energy from atomic sources. For this purpose helium is proposed as the working fluid and

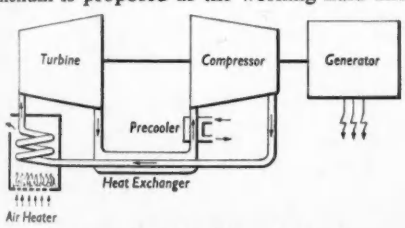


Fig. 10—Escher Wyss closed cycle

it has been found to possess very good heat exchange qualities, and is convenient for reactor work.

In the course of a paper which was read by Dr. C. Keller and Dr. W. Spiller, of Escher Wyss A.G., of Zürich, before the recent autumn meeting of the Schiffbautechnischen Gesellschaft in Hamburg, examples of the use of this form of gas turbine using heated air, for naval and commercial ships, were discussed and it was stated that designs were ready for 12,000kW installations, and design work was proceeding for sets giving up to 50,000kW propulsive power. The working temperatures of these sets would be about 650 deg. Cent. and the use of pressure-equalising regulation in the working circuit would do away with the usual governor. It was claimed that the small dimensions of the new design and lower weights, together with increased range of operation and more efficient cruising speeds, would be advantageous for naval vessels. With oil fuel of 10,000 kilo calories per kilogramme, the fuel consumption at normal load works out at about 210 grammes per shaft horsepower.

Similar advantages are claimed for passenger liners and cargo vessels and it was pointed out that the new design of heat exchanger had enabled a heat transmission of thirty times the old design to be safely used. Thin walled tubes could be employed as the maximum temperature ranges from 50 deg. to 75 deg. Cent. only, and could be further reduced by the use of tubes with internal ribbing.

With regard to the tubing connected with the gas turbine, the construction used gave a life of 50,000 to 100,000 hours at turbine temperatures up to 680 deg. Cent. Should it be found desirable to increase the circuit temperatures up to, say, 700 deg. to 750 deg. Cent., these temperatures could be limited to a small section of the air heater and such parts would, it is expected, have to be changed after perhaps 20,000 hours.

Oerlikon Engineering Company, Zurich

We learn from Oerlikon, Ltd., of Victoria House, Southampton Row, London, W.C.1, that at the works of the Oerlikon Engineering Company of Zurich, Switzerland, the main work during 1954 was the completion and setting to work of the 730kW gas turbine-driven generating set ordered by the Compagnie de Electricite et Gaz of Algiers, for its Bone II power station. We may recall that this set is of particular interest as it has been designed to work with the two auxiliary steam boilers, which provide the necessary steam used for the injection of heavy oil fuel into the main boilers. These main boilers provide steam for the two 25,000kW steam turbine-driven generating sets installed in the power station. A grade "C" of heavy boiler fuel is used which has a viscosity of 500 deg. Engler or 15,400 Redwood N.I. at a temperature of 68 deg. Fah. The exhaust gases from the gas turbine are released at a temperature of between 572 deg. to 752 deg. Fah. and contain up to 70 or 80 per cent of their original oxygen content, which enables them to be used in the boiler furnace with a full recovery of the waste heat.

The set was completed towards the end of 1954 and in Fig. 11 we show a view of the complete unit on the test bed at the Zurich works. Looking from the left to the right, on platform level, the switchboard will be seen with the gas turbine and compressor.

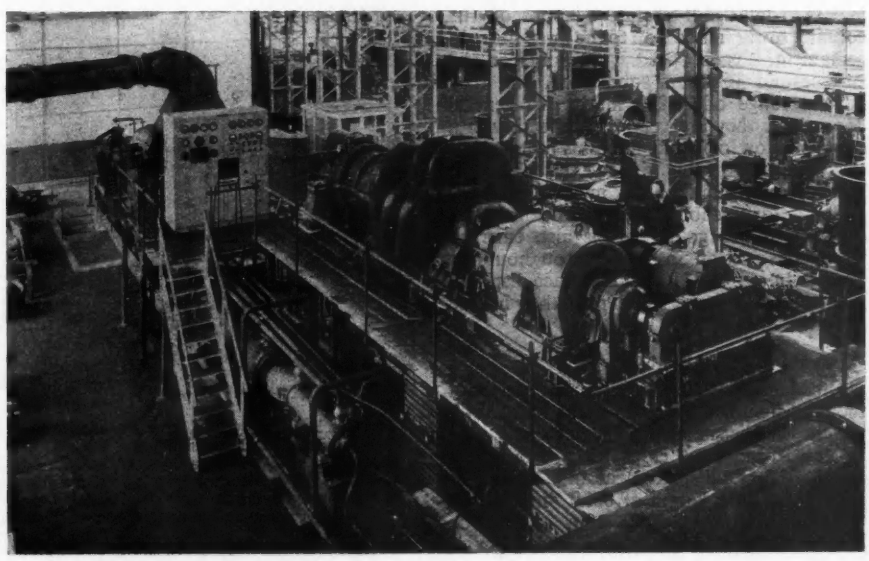


Fig. 11—730kW Oerlikon gas turbine set on test. The exhaust is used as combustion air in a steam cycle

This is of the centrifugal pattern having four diffusers for each of the three stages. The turbine and compressor run at a speed of 5250 r.p.m. and drive the 915kVA Oerlikon alternator at a speed of 1500 r.p.m. through Maag reduction gearing. At the right-hand end of the set the exciter and the geared starting motor will be seen. The set was erected in the Bone station before the end of the year and preliminary trials showed that it ran well and the expected output was obtained. It is intended to run acceptance tests next month when full performance figures will be available.

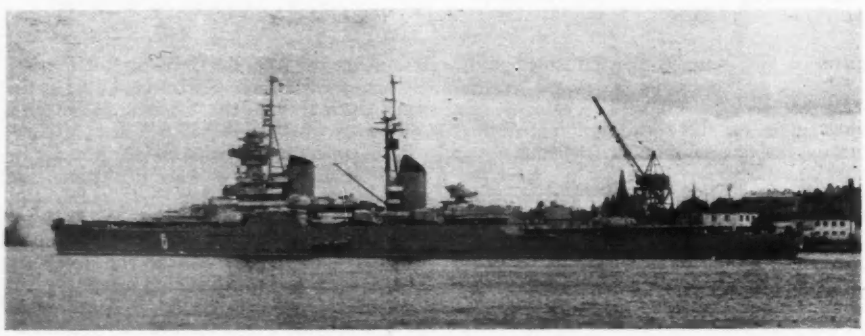
Naval Construction in 1954

RAYMOND V. B. BLACKMAN

No. III—(*Concluded from page 66, January 14th*)

RUSSIA

SIX more cruisers of the "Sverdlov" class (illustrated) were completed during the year and six others were under construction, bringing the number of ships in this class up to eighteen. The average time taken to build each cruiser of this class was two and a half years.



This new cruiser of the "Sverdlov" class has a nominal displacement of 12,800 tons standard and a full load displacement of 17,000 tons with a length between perpendiculars of 656ft, an overall length of 689ft, a beam of 65ft 9in, a mean draught of 16ft and a maximum draught of 24ft 6in. Her armament consists of twelve 6in (150mm) in four triple turrets, two forward and two aft, twelve 3·5in (88mm) dual purpose weapons in six twin mountings, two abreast the bridge and four around the after funnel, thirty-two 37mm anti-aircraft pieces distributed about the forward and after superstructures, and ten 21in torpedo tubes in quintuple banks, one on each side amidships.

Twelve more destroyers of the "Skori" class (illustrated) were commissioned, bringing the total number of this type up to fifty-eight, with another ten under construction. Twenty very large ocean-going submarines of new construction were completed and commissioned for service. These have a submerged displacement of 2900 tons with a length of 320ft. They are armed with twin 3in guns in a turret before the conning tower and twin light anti-aircraft weapons on the conning tower in addition to the large torpedo armament. Their speed is 20 knots on the surface and 16 knots submerged, and they have a range of 20,000 miles. In general appearance they are very streamlined with a complete row of rapid flooding holes along the casing. A submarine of this class can be constructed in about six months.

Some forty submarines of medium size designed for seagoing patrols also emerged from construction in yards throughout the Soviet Union. Of 1100 tons surface displacement and 1600 tons submerged they have a length of 240ft.

FRANCE

On May 28, 1954, a new aircraft carrier of the large light fleet type, known as "P.A. 54," which will be named "Clemenceau," was ordered from Brest Dockyard. The design provides for a displacement of 22,000 tons standard with a length of 833ft 4in between perpendiculars and 844ft 10in overall, an extreme breadth of 141ft and a draught of 26ft 3in. She will carry about sixty aircraft with an armament of twenty-four 2·25in (57mm) Bofors anti-aircraft guns in twin mounts. Her propelling machinery will include geared turbines of 126,000 s.h.p., estimated to give a speed of 32 knots.

Bad luck attended the second "launch" of the new anti-aircraft cruiser "De Grasse," which already had a chequered and vicissitudinous building history behind her. She was to have started her first acceptance trials in August, 1954, but on June 26, 1954, when she was being floated up in the new dock at Brest arsenal, she flooded owing to a sea cock having been left open. This vessel was laid down as a conventional cruiser in November, 1938, but her construction was suspended during the German occupation of Lorient, and work was not resumed until 1946. After she was launched on September 11th of that year, however, building was again stopped pending the study of new anti-aircraft equipment and owing to the stringent financial situation then prevailing. It was finally decided to complete her as an anti-aircraft cruiser, and her construction was eventually restarted on January 9, 1951, since when she has been converted and fitted out in Brest Dockyard to a modified design with modern armament. Her displacement is now given as 9000 tons standard and 11,300 tons full load, with a length of 592ft, a beam of 60ft 4in and a mean draught of 18ft 2in. She is armed with sixteen 5in anti-aircraft guns in twin mountings, four forward and four aft, and twenty 57mm A.A. Bofors weapons, also in twin mountings on the forward and after superstructures. Her propelling machinery consists of four boilers and Rateau-Chantiers de Bretagne geared turbines turning two shafts and developing 120,000 s.h.p., equal to a speed of 33·5 knots. She began her sea trials at the end of October.

A new anti-aircraft cruiser, designed as such from the beginning, the "Colbert," the construction of which was started in Brest Dockyard early in the year, will be an improvement on the "De Grasse," with new protection quite different from that of her predecessor, and a platform for a helicopter. Provision has also been made in the design so that she can be fitted eventually with guided missiles. The "Colbert" will displace 8500 tons standard and 11,000 tons full load, with a length of 574ft 2in and a beam of 63ft 4in. Her armament will include sixteen 5in A.A. guns in twin mounts and twenty-four 57mm A.A. weapons (twin Bofors). The propelling machinery will be of 86,000 s.h.p., designed for a speed of 32 knots and the radius will be 4000 miles at 25 knots.

The reconstruction of the two light cruisers surrendered by Italy to France, the

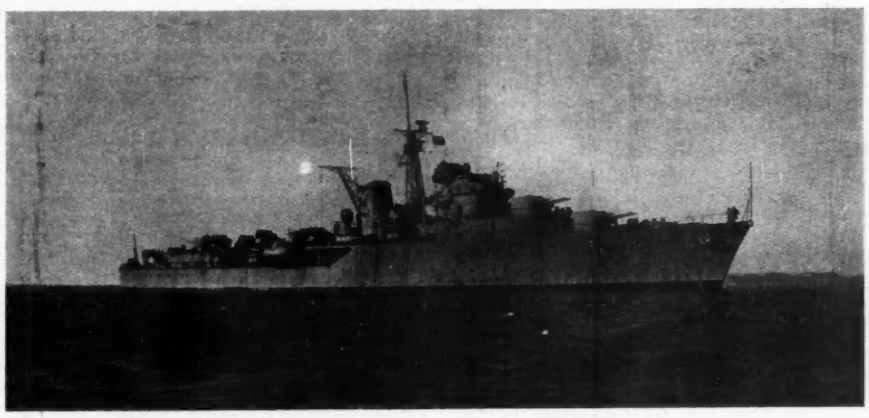
Fast minelaying type of large fleet destroyers known as the "Skori" class, equipped with modern target-finding and gun-sighting radar. With a displacement of about 2200 tons, these ships have a length of 393ft 9in, a beam of 37ft 6in and a draught of 13ft 1½in. Their armament comprises four 5·1in guns in two twin turrets, one forward and one aft, two 3in anti-aircraft guns in a dual mounting aft, seven to ten 37mm A.A. weapons, six 20mm A.A. pieces, eight 21in torpedo tubes in two quadruple nests amidships, one abaft each funnel, four anti-submarine depth charge-throwing weapons and eighty mines. Their propelling machinery comprises a two-shaft arrangement of steam geared turbines of about 70,000 s.h.p. designed for a speed of 38 knots. Some 250 officers and men form the ship's company

The name ship of a large class of new destroyers for the French Navy, the "Surcouf" has a displacement of 2750 tons standard and 3700 tons full load with an overall length of 420ft and a beam of 41ft 8in. Her armament includes six 5in dual purpose guns in three twin turrets, six 2·25in (57mm) Bofors A.A. weapons in three twin mountings, and twelve 21·7in torpedo tubes. The main propelling machinery comprises two geared turbine installations developing some 63,000 s.h.p. turning two screws to give a maximum of 34 knots steaming light and 32 knots at full load

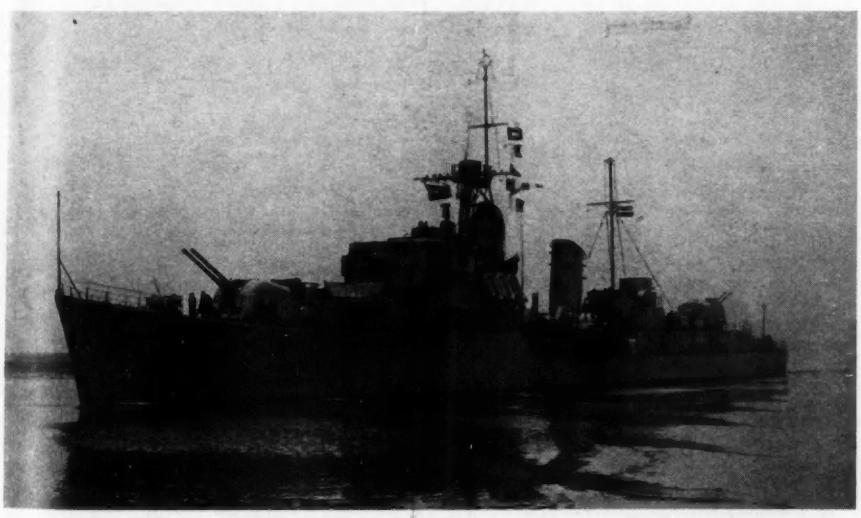
"Chateauremault" (ex-"Attilio Regolo") and "Guichen" (ex-"Scipione Africano") (illustrated), taken in hand in the summer of 1951 for conversion to anti-submarine and anti-aircraft vessels, was completed on April 1 and July 1, 1954, by Forges et Chantiers de la Mediterranée, La Seyne Dockyard, and they are now rated as *escorteurs rapides*, equivalent to destroyers, despite the fact that they have cruiser displacements and dimensions. Their cruiser armament has been replaced by a lighter and more modern high-angle battery and improved anti-submarine weapons.

Of the seventeen new vessels of the "Surcouf" (illustrated) class, designed as *escorteurs rapides anti-aerien*, but re-rated as *escorteurs de première classe* in 1951 and as *escorteurs rapides* in 1953, twelve have been launched and six of these were completed in 1954.

Of the thirteen new vessels of the "Le Corse" class, designed as *escorteurs rapides anti-sousmarins* but re-rated as *escorteurs de deuxième classe* in 1951 and as *escorteurs* in 1953, more than half have been launched and four of these were completed in 1954. They have a displacement of 1290 tons standard and 1702 tons full load with a length of 315ft and a beam of 33ft 6in. Their armament includes six 2·25in (57mm) anti-aircraft guns in twin mounts, two 20mm A.A. weapons, two anti-submarine mortars, a depth charge rack, quadruple *lance-roquettes*, and twelve 21·7in torpedo tubes in four triple mountings for new special homing torpedoes. Their propelling machinery comprises geared turbines of 20,000 s.h.p. designed for a speed of 27 knots.



Built by Vickers-Armstrongs, Barrow-in-Furness, this powerful destroyer the "Nueva Esparta" is in appearance reminiscent of the British "Battle" class destroyers, but has the big-gun armament and lay-out of the "Daring" class, the length of which she exceeds by 12ft. With a displacement of 2600 tons standard and 3300 tons full load, she has an overall length of 402ft with a beam of 43ft and a draught 12ft 9in. Her armament comprises six 4·5in guns in twin turrets, two forward and one aft, eight 40mm A.A. weapons, three 21in torpedo tubes, two depth charge-throwers and two depth charge racks. Parsons geared turbines of 50,000 s.h.p. turning two shafts, give her a speed of 34·5 knots



The name ship of a class of four new anti-submarine escort destroyers, the "Holland" was completed in February, 1954. She has a displacement of 2164 tons standard and 2765 tons full load with a length of 360ft 6in between perpendiculars and 371ft overall, a beam of 37ft 6in and a draught of 12ft 6in. Her armament includes four 4·7in guns in two twin turrets, one forward and one aft, and her propelling machinery comprises geared turbines of 45,000 s.h.p., turning two screws and equal to a speed of 32 knots

While the above ships of the "Le Corse" class may be used for leaders, for normal convoy duties a simpler type of frigate has been evolved with the same anti-submarine armament, but a smaller displacement of 1000 tons standard with a length of 292ft and a beam of 31ft 4in. Their armament will include four 40mm A.A. guns in twin mounts. The somewhat simple propelling plant will include a geared turbine installation turning one shaft and developing 15,000 s.h.p., designed for a speed of 25 knots. This new utility French type has been initiated with three vessels to be built at Lorient. The total number of this class of escorts envisaged is forty.

Four new ocean-going submarines being built at Cherbourg have a displacement of 1441 tons on the surface and 1800 tons submerged, with a length of 256ft and an armament of eight torpedo tubes. Their propelling machinery comprises Schneider diesels of 4000 b.h.p., equal to a surface speed of 16 knots, and electric motors of 5000 h.p., giving a submerged speed of 18 knots. They are being built in seven prefabricated parts of 10m in length. Four submarines of the killer type for hunting enemy submarines are also under construction at Cherbourg.

Several of the thirty-seven new coastal minesweepers of the "Sirius" class were completed in French yards, and of other new construction coastal minesweepers, thirty-six were acquired from the United States and six of the "Gaspe" class (*q.v.*) from Canada. Twelve new construction fleet minesweepers were acquired from the United States (*q.v.*) and a number of new inshore minesweepers in Great Britain under the U.S. off-shore procurement programme which is also providing for nine coastal escorts under construction in France.

Italy

Two vessels originally built as light cruisers of the "Capitani Romani" class, the "San Giorgio" (ex-"Pompeo Magno") and "San Marco" (ex-"Giulio Germanico") were still under reconstruction. They are being converted into anti-aircraft and anti-submarine destroyers or fast frigate squadron leaders by Cantiere del Tirreno, Genova, and Navalmeccanica Castellammare di Stabia. The two large destroyers "Impetuoso" and "Indomito," laid down by Cantieu di Tirreno, Riva Trigoso and Ansaldo, Leghorn, respectively, on May 7 and April 24, 1952, were well advanced.

Of the three frigates or escort destroyers rated as *cacciatorpediniere di scorta* with special anti-submarine and medium anti-aircraft armament, two, the "Canopo," laid down by Cantieri Navali di Taranto on May 15, 1952, and "Centauro," begun by Ansaldo, Leghorn, on May 31, 1952, and launched on April 4, 1954, were nearing completion. The third ship, "Cigno," is being built to the order of N.A.T.O. for the Italian Navy.

Netherlands

Eight vessels of a hybrid kind akin to both destroyers and fast ocean-going anti-submarine frigates were in various stages of construction. They are bigger than the more normal-sized new destroyers "Holland" (illustrated), "Gelderland," "Noord Brabant" and "Zeeland," just completed. They were designed on destroyer lines with large destroyer displacement and dimensions, but they have no torpedo tubes like normal destroyers. They are also unusual in having some side armour as well as deck protection, in which respect they are like light cruisers, but in the Netherlands they are referred to as "submarine chasers," indicative of their designed role. They will displace 2476 tons standard and 3070 tons full load with a length of 370ft between perpendiculars and 380ft 6in overall, a beam of 38ft 6in and a draught of 13ft. They will be armed with four 4·7in guns, six 40mm anti-aircraft pieces, and anti-submarine weapons. Their propelling machinery comprises a two-shaft arrangement of geared turbines developing 60,000 s.h.p. and designed for a speed of 36 knots.

Sweden

The completion of two large destroyers with fully automatic gun turrets, was delayed by a hold-up in the fitting of the new armament. Launched on July 16 and October 23, 1952, respectively, by Götaverken and Eriksberg, they have a displacement of 2600 tons with a length of 380ft 6in and a beam of 41ft. They will carry four 4·7in guns, two 57mm A.A. weapons, six 40mm A.A. pieces, and eight 21in torpedo tubes at a speed of 35 knots. Four later destroyers, under construction, will displace 2000 tons and carry four 4·7in guns and six 21in torpedo tubes at a similar speed.

Venezuela

Of the three large destroyers ordered from Vickers-Armstrongs, the "Nueva Esparta" (illustrated) and "Zulia," were completed and ran final trials in 1954. Both were laid down on July 24, 1951. The "Nueva Esparta" was launched on November 19, 1952, and the "Zulia" was launched on June 29, 1953, on the same day that the third ship, the "Aragua," was laid down.

Civil Engineering in 1954

No. III—(*Concluded from page 44, January 14th*)

THE most notable hydro-electric scheme of 1954 was undoubtedly the Owen Falls dam and power station, built across the Victoria Nile in Uganda ; it was inaugurated last April, and was fully described in THE ENGINEER at that time. The decision to build the scheme has been described as "an act of faith," for there was little electrical load demand in the area when construction was started, and the scheme was built with the idea of attracting industry and developing the Protectorate generally by providing a cheap and abundant power supply. This policy has now been justified to the extent that, according to a recent report, the chairman of the Uganda Electricity Board has stated that a new scheme will be needed by 1960.

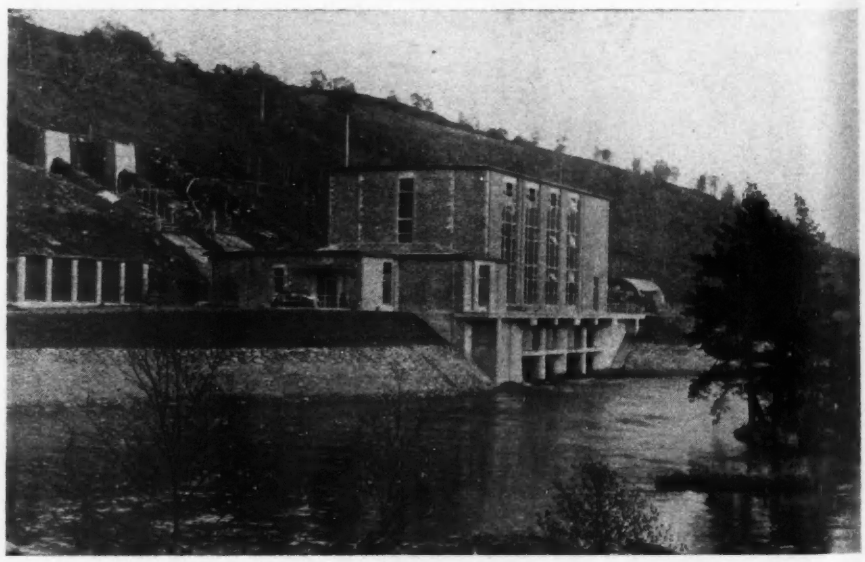
One aspect of the Owen Falls scheme is, we believe, unique : that is the effect of the enormous reservoirs of Lake Victoria, immediately upstream from the dam. Raising the lake by 4ft is envisaged, which will give an additional storage capacity of 55,000,000 acre-feet, the total storage being 166 million acre-feet. Records of the flow of the Victoria Nile at this point have been kept for fifty-two years and show a variation over a range of only about 4 to 1 due to the regulating effect of the lake. However, a considerable proportion of the water flowing into the lake is lost by evaporation, and it is not certain to what extent evaporation losses would be changed by water conservation schemes around the shores of the lake. It was stated at the Institution of Civil Engineers' discussions on the scheme that a survey of the water resources around the lake is to be made. It was also pointed out by one speaker that the effect of Lake Victoria was so marked that, even if there had been a miscalculation about the size of the spillway and there had been floods which eventually might have overtopped the dam, there would still have been plenty of time to enlarge the spillway before any disaster had occurred. The additional storage envisaged from raising the lake level might in fact take eight to seventeen years to build up, it was also pointed out. The consulting engineers for the scheme were Sir Alexander Gibb and Partners and Messrs. Kennedy and Donkin, and it was built by a consortium of contractors, the Owen Falls Construction Company.

The more modest hydro-electric schemes at home also made noteworthy advances in 1954, and the North of Scotland Hydro-Electric Board inaugurated the Luichart section of its Glascarnoch-Luichart-Torr Achilty scheme last September. The entire scheme will yield 450 million kWh annually from an installed capacity of 107MW. The section completed last year comprises the Luichart dam, diversion works, and power station, and the dam and power station are illustrated herewith.

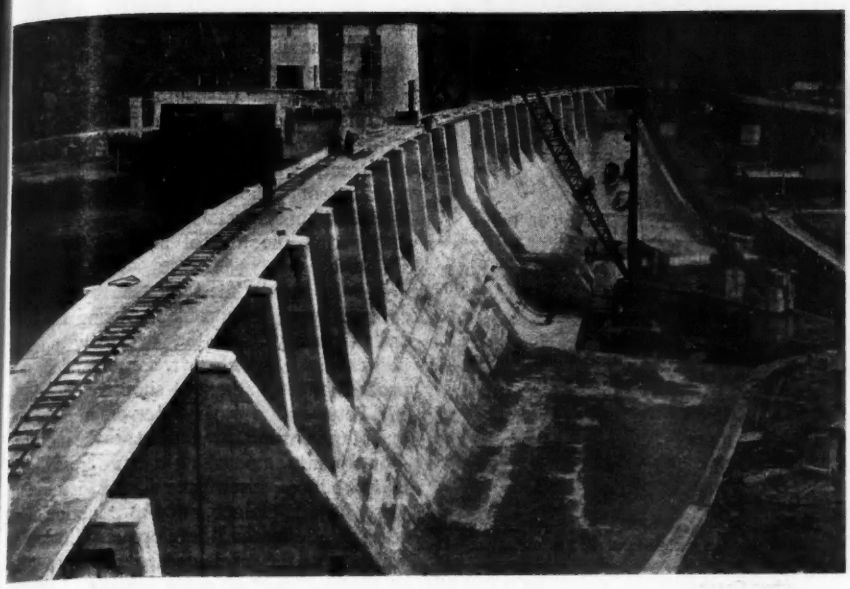
The Luichart dam at the outlet of Loch Luichart is of gravity section built of mass concrete. It is 45ft high and 680ft long and has raised the water level of Loch Luichart by about 40ft, thus rendering necessary the realignment of nearly 2 miles of railway line between Dingwall and the Kyle of Lochalsh. The bridge above the spillway which runs the whole length of the dam has a pre-stressed concrete deck. The dam incorporates a Borland fish lift ; fish are first attracted into the bottom end of a large shaft on the downstream face of the dam ; the lower outlet of the shaft is then closed and as water continues to pour in the level rises and the fish rise without effort until they have reached the upstream end and can swim on into the reservoir. The upper end of the fish lock structure is combined with the intake to the main pressure tunnel so that the flow entering the tunnel provides the necessary attraction for fish ascending and descending the fish pass. The pressure tunnel is 4090ft long and is of "D" section, 16ft wide, and is lined with concrete throughout.

Just above the lower portal of the tunnel is a surge chamber, 95ft deep and 65ft in diameter. The lower end of the tunnel is steel lined and is connected to two pipelines, each 11ft diameter, terminating at the Luichart power station. This power station is just above the junction of the River Meig and the River Conon. It has walls 2ft thick of solid stone from Tarradale with a steel framework carrying the roof and crane beams. The stonework in the interior has been left exposed ; no other internal decoration has been used. The stone building was completed in six months.

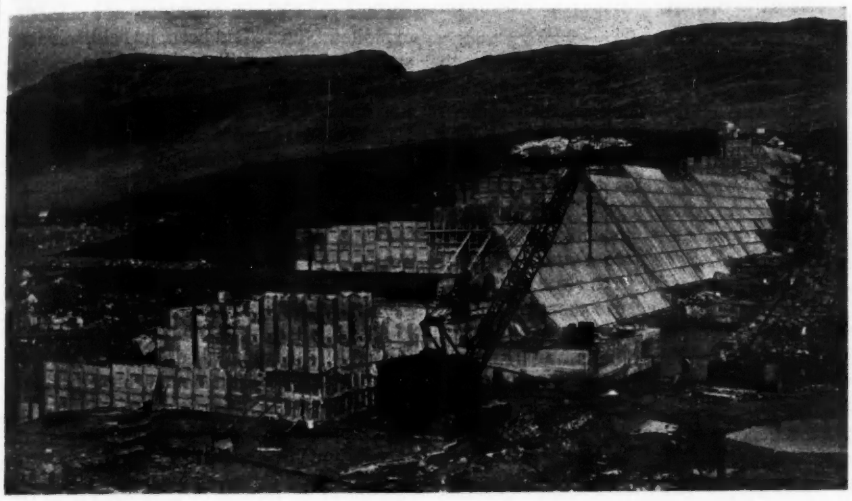
The generating machinery consists of two 12MW Francis turbine-driven alternators (gross head 185ft), and the station will have an estimated annual output of 124 million kilowatt-hours. The plant has been so designed that a minimum staff is required to operate it. Normally one attendant only is required and to set a machine in operation and to bring it on load only the pressing of one button is necessary. Sir Alexander Gibb



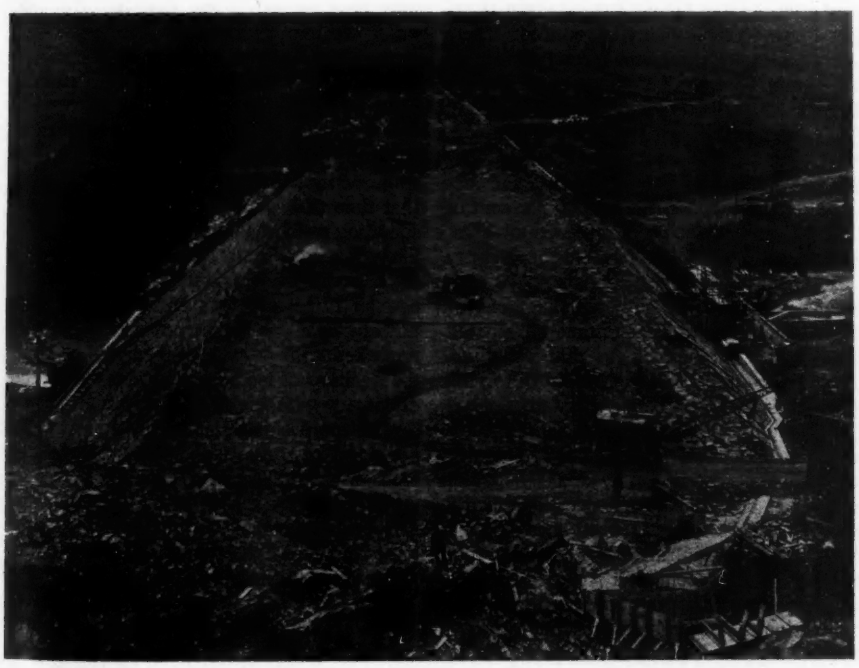
Luichart power station. Two 12MW Francis turbo-alternator sets are installed and the annual output is about 124 million kWh



Luichart dam, a gravity structure, 45ft high and 680ft in length. The dam incorporates a Borland fish lift



Cluanie dam of the Moriston scheme, under construction. When completed the dam will be 125ft high and 2165ft long



Progress of the Quoich rock-fill dam last November. The completed dam will be 130ft high and 1060ft long

and Partners are the consultants for the civil engineering work, and Messrs. Merz and McLellan for the power station plant and equipment. The contractors for the civil works were Reed and Mallik, Ltd. (dam), George Wimpey and Co., Ltd. (tunnel), and Duncan Logan (Contractors), Ltd. (power station).

On the upper Moriston works of the North of Scotland Hydro-Electric Board, the placing of Trief concrete in the Loyne and Cluanie dams made good progress and the dams are expected to be completed this year. Precast concrete blocks were used successfully as shuttering on both dams, as an accompanying illustration shows. The excavation of the Ceannacroc underground generating station and of all tunnels, totalling 5½ miles in length, was completed, and the concrete lining of the tunnels was in hand. Construction of a 7-mile long road diversion along Loch Cluanie continued. The Mitchell Construction Company is the civil engineering contractor for the above works, except the road diversion which is being carried out by the International Development Company, Ltd., of Newark. A start was made on the lower Moriston works, which include a dam, underground generating station 300ft below ground, almost directly under the dam and a 4½-mile long tailrace tunnel ending at the mouth of the River Moriston. The generating plant will comprise two 16MW vertical Francis turbo-alternator sets. The civil engineering contractor is Duncan Logan (Contractors), Ltd.

On the Invergarry works, which form the lower section of the Garry project, about half of the concrete was placed in the dam at the outlet of Loch Garry. In the 3 miles of tunnels about half of the concrete lining was placed and the whole of the steel lining in the downstream section. In the generating station, which is built mostly below ground level, the main structure was completed and plant erection started. The main civil engineering contractor is Whatlings, Ltd. On the Quoich works, which form the upper section of the Garry project, good progress was made with the rockfill for Quoich dam, which is shown under construction in the illustration herewith. Of the two short dams at the western end of the reservoir one was being constructed partly as a concrete gravity dam and partly as rockfill dam with concrete core wall; the other will be entirely a concrete gravity dam. The concrete lining of the 3 miles of tunnels was still in progress. In the generating station the roof was erected and plant erection was in hand. The main civil engineering contractor for these works is Richard Costain, Ltd. Quoich, Invergarry and Ceannacroc generating stations are expected to be commissioned in the autumn of this year and the Glenmoriston station early in 1957. The consulting civil engineers for the Garry and Moriston projects are Sir William Halcrow and Partners and Messrs. Kennedy and Donkin are the consulting engineers for the plant.

STRENGTH OF PLYWOOD.—The Forest Products Research has published its bulletin, No. 33, entitled "The Strength Properties of Plywood, Part 2, Effect of the Geometry of Construction" (H.M.S.O., price 2s.). It is pointed out that plywoods can now be made which are practically indestructible by delamination. They may be considered a structural material, and increasing quantities are being used for such things as box and web girders, panel floors and walls, ships planking and concrete shuttering. The bulletin contains the results of an investigation to provide suitable equations for calculating the bending, tension, compression and shear strengths of any plywood construction. All the tests were carried out on gaboon. From the results, equations were formulated which can be used in practice for calculations on constructions of any other species of wood. As an example, an appendix to the bulletin shows how the equations are used in calculating the bending, compression, tension and panel shear strengths of a ¼in plywood made of different woods.

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AIRCRAFT DESIGN AND PRODUCTION

The fact that so many of the problems basic to the design of supersonic weapons are slowly yielding solutions under the pressure of the present worldwide onslaught upon them tends to obscure rather than to enlighten foresight about the immediate future of aviation. Ours is an era in which subsonic, transonic, supersonic, hypersonic and even nuclear, piloted or guided aircraft have been or may very shortly be demonstrated. In addition—the worse to confound existing confusion—there is the promise of an equally diverse family of ram-jet and rocket guided missiles. Too much seems possible. Yet we cannot yet see where our present hopes will be deceived nor where they will be justified. What eventually proves practicable may fall, indeed, abysmally short of what seems at present possible ; alternatively, practicality may exceed our wildest optimism ! Each new development, of course, threatens its predecessors with obsolescence. Yet each represents a leap in engineering practice that needs consolidation before further progress can be safely made. As we peer further into the not very distant future the performance of each projected craft becomes less certainly predictable ; more and more it becomes difficult to decide whether to concentrate upon this line of advance or upon that. Yet because resources are limited a choice must be made. Equal attention cannot be allocated to every possible line of advance.

An urgent present tangible problem is that of deciding upon the prospects of integral construction. The case for integral construction has been argued for nearly a decade, and it was this aspect of the industry's activity which formed the central theme of the recent production conference at Southampton, a report of which appears elsewhere in this issue. At the present time the demand calls for high-strength aluminium alloy forgings of intricate shape formed with extremely thin sections and generally to very close tolerances ; and for light alloy slabs from which to mill and contour complete wing sections of up to 40ft length. According to experience in America, where it is under extensive development, integral construction is cheap. For in spite of the increased machining costs, there are fewer drawings to be made and component and assembly costs are much reduced. There is also a saving in weight in the finished piece because there are fewer parts, and tapered sections to close tolerances can be called for. Because there are fewer joints the structural efficiency is enhanced and there are far fewer bolts and rivets to create stress concentrations and induce fatigue. For military aircraft which require much reduced wing thickness chord ratios, integral wing construction may well prove to be the only technique by which wings conforming to the critical spanwise and chordwise profile tolerances can be mass produced. Overall there is said to be a very considerable saving in time. But many new forging problems are introduced. There are metallurgical problems largely concerned with grain flow, and high levels of internal stresses can be set up unless care is taken. For wings, very much larger slabs than are at present available are required and similar internal stress problems arise from the fact that in some cases as much as 90 per cent of the slab is milled off ! Experimental work along these lines now in hand in this country was the subject of several papers at the conference. It could be gathered that none of the problems so far encountered has proved insuperable. To implement this technique, however, requires the development of forging and extrusion plant of great size and cost and the development of highly specialised automatic machine tools. A forge of 35,000 tons capacity and costing nearly £3,000,000, not to speak of skin millers costing nearly £250,000, have already been installed in America. For civil aircraft it appears that by adopting the technique America may be able to produce by what amounts to a mass production method a machine superior aerodynamically and cheaper than we could using conventional methods. The reluctance of this country to embark on such a programme is natural. Yet further delay could cause serious consequences. For the effect on the military sphere must be assessed; and it is certainly not practicable to design new military aircraft until at least the method of construction has been decided upon ! The problem of deciding how best to produce aircraft is thus now added to that of deciding upon what the line of advance in design should be.

It is in the darkness induced by the very complexity of the problems facing the aircraft industry that the decidedly critical address with which Mr. Petter ended the production conference should be read. Mr. Petter spoke gravely of errors in planning and of undermining weaknesses in the industry —two points emphasised in his address which is reproduced elsewhere in this issue. It was, he maintained, not production but research, design and development difficulties which were the prime causes of the troubles of this country's aircraft industry. In his opinion, the uses of what are the essentially modest facilities at our disposal have been neither properly co-ordinated nor efficiently exploited. There had been, he held, mistaken specifications and ill-advised objectives, and those who had to fulfil the requirements had not challenged their worth or timing. He went on to express concern about other things. We had, he feared, made the cardinal error of splitting the use of our resources between too many alternatives—" too many channels for too little water " were his words. When American and British engineering philosophy have been compared in the past, it has often been the pride of Englishmen to note that where the Americans at fabulous expenditure of money and effort would bludgeon their way simultaneously through all possible routes without thought of elimination, here more subtle counsel exercising greater ingenuity and intuition has prevailed to discern a single approach upon which boldly to commit and sometimes to gamble our whole resources. But, judging by Mr. Petter's comments on bomber design alone, such counsels have deserted us. There may be, of course, other factors frustrating this traditional approach. Has this country, for instance, a fair minimum of research facilities to cope with the complexities of supersonic investigation ? In America, in 1951, there were claimed to be no less than forty-six supersonic wind tunnels, and it was believed at that time that we had only four. A corresponding ratio may apply to-day. It is quite likely that forty-six is far too many considering their huge cost. But is four even nearly enough ? Mr. Petter's comments on manpower were no more comforting. He remarked " the number of men who combine the qualities of leadership, inventiveness and diplomacy with those of character necessary for the top design job certainly appear to be no more than the number of approved aircraft firms to-day ; apart from the leaders there are hardly sufficient sound lieutenants, the people who really do much of the work, to go round even the good existing teams, and the same is found even more acutely at the level of designers and technicians." He then referred to the inadequate status accorded to such distinguished designers as the industry did have ; and compared it with that afforded

to those who distinguish themselves on the commercial side of the industry. It is, we fear, only too true that many men endowed with the necessary brilliance are deterred from taking up engineering and design in industry because so many other careers offer more clearly defined and certainly more remunerative avenues to success and social achievement. To expedite the construction of wind tunnels and to provide other equipment is relatively easy. To secure the services of men who can make the best use of the equipment is quite another matter.

COMMONWEALTH CONFERENCE OF ENGINEERING INSTITUTIONS

It is an example of the practical good sense of the British people that the British Empire is being, by progressive stages, converted into the Commonwealth, a group of independent nations acknowledging now hardly a vestige of any legal tie. They associate together because they want to, not because they must, and their method in discussion is not to insist upon uniformity, but to seek to develop those affairs upon which there is agreement, agreeing to disagree when unanimity is unattainable. It is upon a similar conception that the major engineering societies of the Commonwealth have modelled their joint proceedings. Those bodies first met in conference in 1946 to study whether they could establish a closer collaboration than had up to that time existed. They found they could. The January issue of the *Chartered Mechanical Engineer* records some of the results of the third such conference held in London at the end of May last year. The degree of unanimity built up during the eight years since 1946 proves to be remarkable. Yet it is not complete. The record shows that the Institution of Engineers in Australia has been unable to accept three recommendations accepted by the home Institutions of Civil, Mechanical and Electrical Engineers and by similar institutions in Canada, India, New Zealand and South Africa, and that the New Zealand Institution of Engineers has doubts about accepting another. Such differences of view are not unexpected when men from vastly different territories meet together. It is, indeed, healthy that they should occur, for minorities are not always wrong. But it is far more important to notice how very much wider the fields of agreement are becoming than those in which differences of approach still exist.

Of course, since all the societies involved are undertaking similar work it is not at all surprising to find that discussions at the conference embraced just about the whole gamut of the activities we associate with the home institutions. The subjects covered education, the supply and demand for professional engineers, the importance of conserving natural resources, public relations, reciprocal facilities for members in constituent institutions, abstracting services, codes of practice, extra-territorial activities and relationships with other international associations of engineers. Educational activities prompted much attention. In particular, the machinery for bringing overseas students to this country for training and the nature of the training offered was discussed. Full support was given to the idea, and it was felt that even more should be done to provide facilities for practical training not only in Britain, but in other oversea territories; but some criticism, no doubt very salutary and useful, seems to have been expressed about the nature of the training provided. Again, the institutions were united in desiring to bring about a raising of the status of engineering as a profession. The problem of getting schools and schoolmasters to appreciate the possibilities of careers in engineering is, it seems, common to all the countries concerned in the conference. Probably the need to stimulate recruitment to the engineering profession reflects the fact that upon a world-wide scale the importance of engineering industries is growing relatively to that of others. Another educational recommendation adopted at the conference possibly reflects concern amongst the constituent institutions about the consequences of setting up technological colleges in relatively undeveloped territories. It stresses the call in practical training for "an adequate range of engineering activities under organised supervision"; and, in the assessment of responsible experience, "of placing suitable emphasis on the need for responsibility as an engineer." Those and many other examples of a common approach amongst the institutions to engineering problems far outweigh in importance the differences in opinion revealed at the conference about, for example, definitions of professional engineers and technicians, the drawing up of codes of practice, and certain matters of education. Quite probably those differences will be resolved when the conference next meets in Australia in 1958.

The proceedings of the Conference of Commonwealth Engineering Institutions should not be studied in isolation. Maybe the growth of an international outlook has been stimulated by war experience; maybe improved facilities for air travel have had something to do with it; maybe the increasing industrialisation of the world has helped to bring it about; but certainly engineers in many lands since the war have become more acutely aware that they are all striving to solve similar problems. Our home institutions were quick to appreciate that situation. They have become related to institutions abroad not only in the Commonwealth, but in Europe, too, through EUSEC, a conference of engineering societies in Western Europe and the United States. Furthermore, through Canadian representation in the Commonwealth grouping and United States representation in EUSEC they have acquired a contact with a third grouping, UPADI, a Pan-American grouping of engineering societies. Thus there are links between all the major engineering societies of the Western world. There are great advantages. It is a natural tendency for bodies situated in widely separated territories to diverge in their policies. Constant contact between them checks that tendency. It helps also to spread knowledge not only through pedestrian but important services like abstracting, but also by bringing engineers from each participating country into contact with those from others and by facilitating the presentation of lectures and papers by eminent men within the borders of countries other than their own. To individuals, particularly younger men, co-operation means that their degrees and qualifications are recognised for what they are wherever they may travel, and that wider facilities for oversea training are opened before them. Above all, international effort by the institutions is likely to lead to a higher appreciation by laymen of the importance to modern civilisation of the work of engineers. Registration, as a means of regulating the status of engineers, was discussed at the conference. It is, perhaps, significant that the members of the New Zealand Institution of Engineers, in qualifying their assent to a recommendation opposed to registration, felt that "with the present increasing prestige" of their Institution "the advantages offered by registration are diminishing."

Obituary

HERBERT CHATLEY

WE regret to record the death of Herbert Chatley, D.Sc., M.I.C.E., which occurred on January 17th. Mr. Chatley was sixty-nine years of age, and was well known as an authority on dredging and dredging plant, of which he had had long practical experience; he was the author of many publications on that topic, but his interests were wide and he also wrote on the theory of flight and on rocket propulsion.

Herbert Chatley was born on May 17, 1885, and educated at Cambridge House Grammar School, North London, and the Northern Polytechnic of London University; he received an external B.Sc. degree in 1906 His early experience included a pupilage under Mr. Arthur Tighe, a post under the borough engineer of Fulham, and a post as Lecturer in Civil Engineering at the Municipal College, Portsmouth. In 1909 he became Professor of Civil Engineering of the Chinese Government Engineering College at Tongshan, in Northern China, thus commencing an association with the country where he was to spend a large part of his professional career. Whilst in the professorial chair at Tongshan, he was awarded a D.Sc. degree at the University of London, in 1914, for research on rolling friction and convex contact.

Chatley returned to practical engineering in 1915, when he started work as an engineering assistant on the Nanking–Hunan railway. In 1916, he joined the engineering staff of the Whangpoo (or Huangpu) Conservancy Board, a body responsible for maintaining the Whangpoo River at the port of Shanghai, and the mouth of the Yangtze River, and remained with them for many years, rising to the position of chief engineer of the Board, until, before the war, he returned to London and carried out consulting work. It was during the long period of his service with the Whangpoo Conservancy Board (for which he was decorated by the Chinese Government) that Mr. Chatley became an authority on dredging, for a considerable amount of dredging—valued at £100,000 and involving 3,000,000 cubic yards annually in 1928—was carried out under his direction. His work included the supervision of the construction of locally built dredging plant and his experience with this class of work resulted in a number of papers such as one entitled "Silt," published in the *Minutes of Proceedings of the Institution of Civil Engineers* of 1920–21 (page 400), which relates to the Huangpu and Yangtze regimes at Shanghai,

and with silt surveys. The result of other work in this area was embodied in several Institution papers relating to the design and construction of dredging plant, the proportions of the dredged materials, the theoretical problems involved, and the hydrology of the Yangtze River. His most recent paper, "Dredging Machinery," was published in the *Journal of the Institution of Civil Engineers* of April 1945, but his Vernon Harcourt Lecture, delivered in 1951 and entitled "Regime and Rhythm in Waterways," has not been published. He was a prolific author, his writings including various papers to the Engineering Society of China.

Herbert Chatley was elected to associate membership of the Institution of Civil Engineers in 1920, and became a full member in 1928; he was also a member of the Institution of Civil Engineers of Ireland, an associate fellow of the Royal Aeronautical Society, and an associate of the Institute of Physics. He was an active member of the Junior Institution of Engineers, of which he was chairman in 1939–40.

W. A. YOUNG

We regret to have to record the death of Mr. William Arthur Young, of Halstead, Essex, which occurred on January 13th, at the great age of eighty-seven. He was well known to many engaged in the engineering and iron and steel industries by reason of his long association with the ironmongery trade, and as editor of *The Ironmonger*, on the staff of which journal he served from 1900 until his retirement in 1934. Mr. Young was born at Cambridge in 1867, and after completing an apprenticeship with Mr. Alexander McIntosh in that city, he added to his experience of the ironmongery business in various parts of the country. He joined *The Ironmonger* as a technical sub-editor and succeeded to the editorial chair in 1925. Mr. Young had a vast knowledge of the trade he served so well, and particularly of its manufacturing and workshop side. He was a lucid writer, and a genial and knowledgeable conversationalist. Mr. Young was one of the founder-members of the Newcomen Society for the Study of the History of Engineering and Technology, and contributed several papers to its transactions. He served as president of the Society in 1938–39, and until a year or two ago was an enthusiastic participant in its summer meetings. Mr. Young was an acknowledged authority on silver and was the author of a standard work entitled *The Silver and Sheffield Plate Collector*. He was also a keen student of Kipling's works and at one time edited the journal of the Kipling Society.

THE ENGINEER Buyers Guide

THE 1955 edition of *The Engineer Buyers Guide* has just been published and one free copy is being despatched by post to all subscribers on our lists. Arrangements have also been made for all regular readers who obtain THE ENGINEER through newsagents to receive a copy, which should be delivered to them with the current issue. There are now over 25,000 entries arranged under about 1900 classified headings in the "Buyers Guide" section, with 900 cross references to help the user find what he wants. Any subscriber or regular reader not receiving a copy should write to The Manager, THE ENGINEER, 28, Essex Street, Strand, London, W.C.2. Extra copies are obtainable at 5s. each, including postage.

Electrical Engineering in 1954

No. III—(*Concluded from page 63, January 14th*)

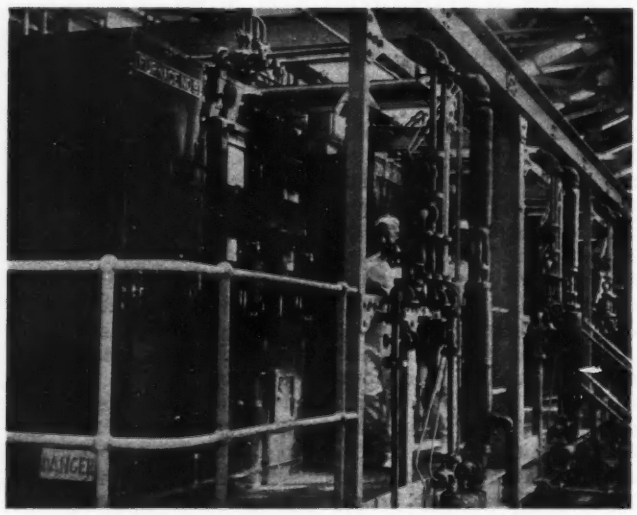
A NEW kind of electrical machine which can be operated either as a coupling or as an alternator has been produced by the British Thomson-Houston Company, Ltd., as a development of that firm's electromagnetic coupling for marine propulsion.

This machine is particularly suited to bulk cargo carriers for the transport of ores, coal, cement, grain, &c. Many ships such as these are provided with self-discharging machinery for handling the particular cargo and, when this machinery is electrically driven, a substantial generating capacity may be required. In the smaller ships of between 1000 and 3000 tons deadweight the space taken by this discharging machinery may be comparable with that taken by the propulsion machinery—an arrangement which is evidently uneconomic.

With the development of the electromagnetic coupling-alternator a much more satisfactory arrangement is possible, for the propulsion engines can also be used to generate electrical power when in port. The machine consists of two assemblies: the inner assembly is the driving member, mounted on an extension of the engine crankshaft, and it carries a salient-pole d.c. field winding; the outer assembly is the driven member, mounted on the propeller shaft, and it carries a three-phase winding. At sea the three-phase winding is short circuited and the machine operates simply as an electromagnetic coupling driving the propeller. When the ship is in port, however, the outer member is locked stationary and the three-phase connections to the winding are established. The inner member is still driven by the main engines and, with the outer member locked, the machine now functions as an alternator which provides power for the motor-driven cargo-discharging machinery.

We learn that the first ship to use this kind of machinery is a twin-screw ship with a coupling-alternator unit on each shaft, and she is expected to join her owner's fleet this year. Each engine is designed to develop 630 h.p. at 250 r.p.m. at sea. In port, with the driving members locked and the three-phase winding connections made the coupling alternators will be driven by the engines at 300 r.p.m. and each will develop 500kW at 440V, three phase, 50 cycles per second.

Elsewhere in this issue, in an article on atomic energy in 1954, we reproduce views of two of Great Britain's atomic factories—the power station under construction at Calder Hall and the diffusion plant at Capenhurst. In the present article, we refer briefly to a typical application of electricity in a third plant, the one at Springfields, near Preston, which is engaged in the preparation and purification of uranium metal. The processes with which we are here concerned are those involved in the conversion of pure ammonium diuranate to metallic uranium, and they are characteristic of a metallurgical works. Conversion of diuranate to metal takes place in two stages. In the first stage the diuranate powder is converted to pure uranium tetrafluoride by heating in an electric furnace in a reducing atmosphere and then passing over hydrogen fluoride gas at a specified temperature, to produce solid uranium tetrafluoride. In the second stage of the conversion the uranium tetrafluoride is removed from the furnace, mixed with chips of calcium metal in a mould and fired, being reduced, finally, to metallic uranium.



Some of the fifty-four G.E.C. furnace control panels at the atomic factory, Springfields, near Preston. They control vertical cylindrical furnaces in which pure ammonium diuranate is converted to metallic uranium

The installation for this process consists mainly of fifty-four vertical cylindrical G.E.C. 100kW furnaces, 200 furnace pots and the associated control gear, cranes and unloading gear. One of the furnace control panels is illustrated here. Each furnace has a heated depth of 6½ft and a maximum temperature of 750 deg. Cent. Forced air cooling is applied to the furnace pots which have a depth of 7ft in and a diameter of 3ft 5in. To overcome corrosion difficulties which were experienced at first with the furnace linings and pipes, "Inconel" linings were provided.

RECTIFIERS

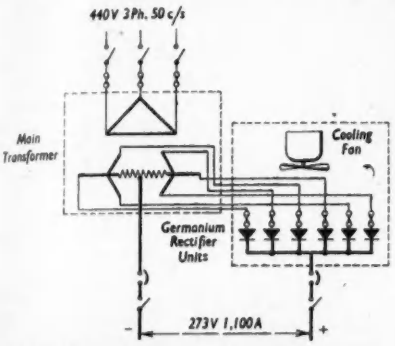
An interesting achievement in rectifier practice was recorded in 1954 when the British Thomson-Houston Company, Ltd., put into service at its Rugby works a germanium rectifier rated at 300kW, 1100A. This equipment, which is believed to be the first application of germanium to power rectification outside the U.S.A., was described and illustrated in our issue of July 9, 1954, page 53.

The development of this germanium rectifier went hand-in-hand with related work on crystal valves in the B.T.H. research laboratories over a number of years, as a result of which it was found that the current obtainable from a germanium "cell" could be raised from a fraction of an ampere to 50A. On this basis the company designed and built a forced-air-cooled rectifier which

was housed in a rectangular cubicle and was capable of giving a rectified output of 1100A at about 270V. A simplified diagram of connections is reproduced herewith. It will be noted that each of the rectifier symbols in this diagram represents a number of germanium cells in series and parallel.

The new rectifier installation has been in service almost continuously since December 21, 1953, operating an electrolyser in the B.T.H. Rugby works and delivering loads mainly approaching its maximum rating. A voltage drop of less than 1V at 50A is characteristic of the rectifier unit and the complete installation has a full-load efficiency of 98·5 per cent.

Further development work is being carried out with the ultimate aim of producing a



Simplified circuit diagram of germanium power rectifier. Each rectifier symbol in the diagram represents a number of units in series and parallel

germanium rectifier suitable for industrial applications of power rectification. One of the lines of inquiry is to study the suitability of germanium as a rectifier for various kinds of service and the company has recently built a second germanium rectifier and put it into operation in the Rugby works, but on a different kind of load.

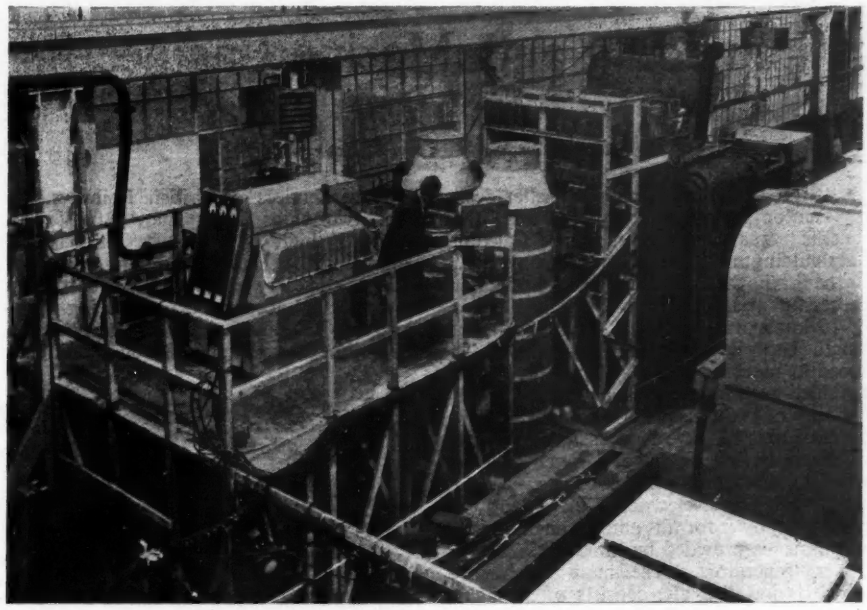
Another class of rectifier which is being investigated by the same company is the mechanical contact rectifier, and during 1954 work continued on the development of a 15,000A, 250V equipment. One of our illustrations shows this contact rectifier undergoing works tests.

Electronic Computing

The value of electronic computing as a means of saving time and labour in mathematical computation is well exemplified, in the aircraft industry, by an analogue computer which has been installed at the Royal Aircraft Establishment, Farnborough.*

This installation is known as "Tridac," a name derived from the phrase "three-dimensional analogue computer." As this name indicates, it is designed to carry out computations in three-dimensional problems such as those involved in interception by piloted aircraft or guided missiles. For example, in the case of a fighter chasing a bomber the motion of the bomber can be reproduced by "feeding" the computer with a prearranged programme, made up of periods of straight flight, slow turns, or violent evasive action. "Tridac" will then calculate the signals that will be received by the radar set in the fighter, allowing for the fact that both fighter and bomber will be moving at high speeds. All the calculations are carried out simultaneously with the actual events, so that, if the fighter bomber interception takes ten minutes in actual flight, then "Tridac" will complete the calculation in ten minutes. While the calculations are being made all the quantities in the problem, expressed as voltages, can be

* The Engineer, October 15, 1954, pages 532-533.



Prototype 15,000A contact rectifier undergoing tests in the B.T.H. works, Rugby. This class of rectifier was originally developed in Germany and has not hitherto been made in Great Britain

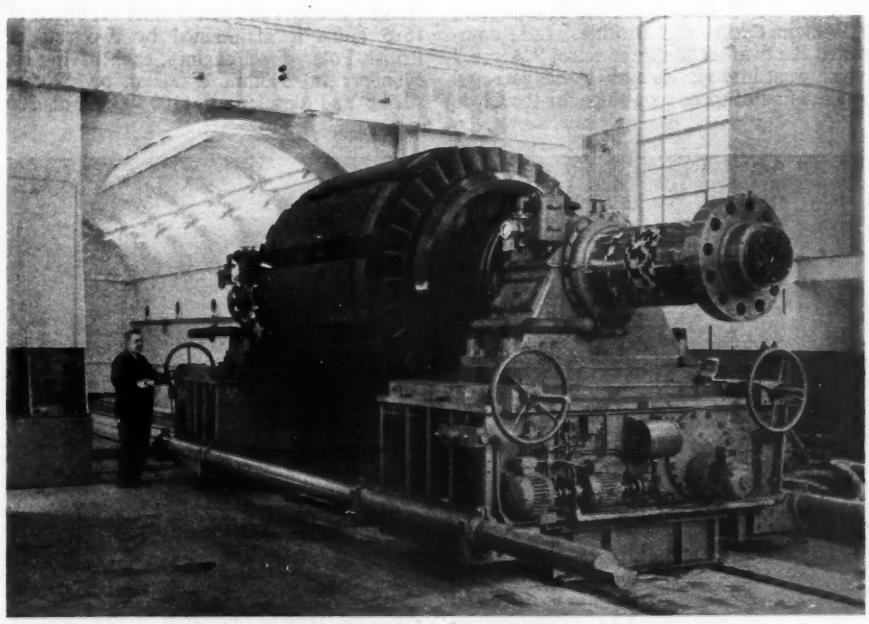
indicated on meters, plotting tables or cathode-ray tubes, giving the operator a picture of what is going on. At any time the operator can stop the calculation and repeat it by setting different aerodynamic characteristics, different speeds for fighter and bomber and different starting points. In this way the chances of an interception in any given conditions can be estimated and the most promising tactics can be formulated.

Similar calculations can be done for guided missile systems including beam-riding, homing and command-link systems. In investigations such as these the use of "Tridac" can reduce the number of missiles that need to be fired for test purposes.

"Tridac" was built by Elliott Brothers (London), Ltd., who collaborated with the Royal Aircraft Establishment in its design. The installation is operated by the R.A.E. and it is available to help the aircraft industry.

A complementary facility was announced in 1954, when Elliott Brothers (London), Ltd., introduced an electronic computing service, as being at the disposal of industry on a machine time hire basis. This service, unlike that given by "Tridac" at the R.A.E. and "Agwac" at the Long Range Weapons Establishment in South Australia, is carried out by digital computing machines taken from the normal Elliott range of production.

The remaining illustration reproduced here shows the rotor of one of the largest high-speed salient pole alternators manufactured in Great Britain. It is a 36MVA, horizontal shaft B.T.H. machine driven at 600 r.p.m. by an overhung Pelton wheel at each end and is designed for a runaway speed of 1100 r.p.m. To meet transport difficulties which imposed a limitation of 40 tons on the maximum weight per load, each pole is secured by four dovetails to a prestressed hollow forging, each end of which is bolted to a stub shaft. All the poles and both stub shafts are removed for shipment.



The rotor of one of two 36MVA, 600 r.p.m. horizontal shaft water-wheel alternators for the Artias hydro-electric power station, Spain. Here the rotor is seen in the balancing and overspeed test house of the British Thomson-Houston Company, Ltd. The test chamber is in the background, left

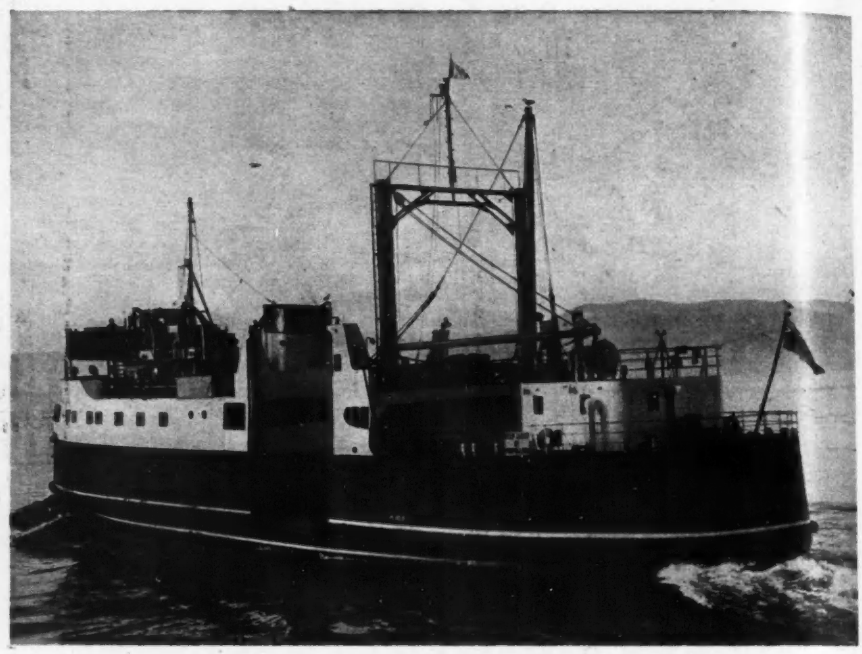
Shipbuilding and Marine Engineering in 1954

No. III—(*Continued from page 51, January 14th*)

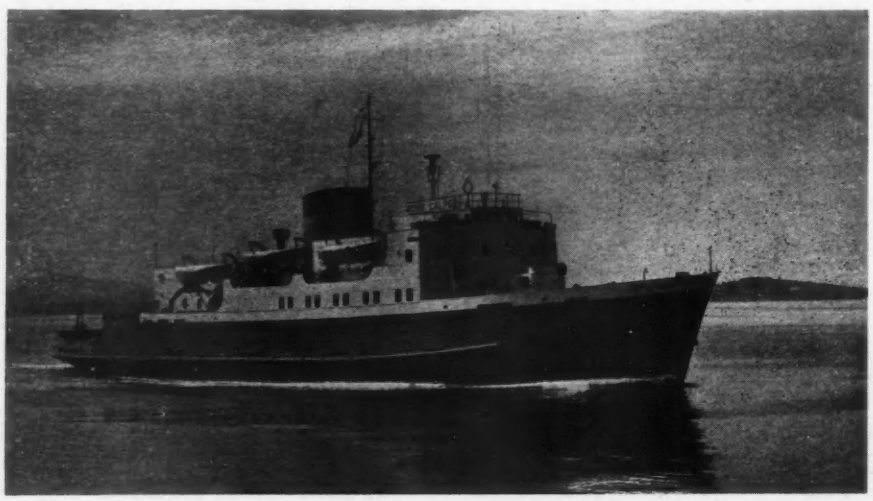
A SINGLE-SCREW, closed shelter deck motor passenger and cargo ship, the "Perlis," was handed over by the Caledon Shipbuilding and Engineering Company, Ltd., to the Straits Steamship Company, Ltd., after successful trials when the specified speed of 10 knots was obtained. The ship has a length between perpendiculars of 195ft, a breadth moulded of 40ft by 19ft depth moulded to the upper deck, and a deadweight capacity of 945 tons on 11ft draught. There are two holds and 'tween decks, a complement of seven derricks and No. 1 hatch is fitted with aluminium alloy hatch covers. All the deck machinery is electrically driven and the necessary power for this and the engine-room auxiliaries is provided by three 75kW diesel-driven generators. The main machinery, which is installed aft, consists of an eight-cylinder, four-stroke, single-acting, pressure-charged Ruston marine oil engine directly coupled to the propeller shafting through reverse reduction gearing having a reduction ratio of 1·94 to 1. The cylinders have a diameter of 10¼in and a stroke of 14½in and at 500 r.p.m. the engine delivers 573 s.h.p.

For its passenger, mail, car ferry, and cargo service between Gibraltar and Tangier the Bland Line, Ltd., ordered the twin-screw M.V. "Mons Calpe" from the Ailsa Shipbuilding Company, Ltd. The ship, which is illustrated herewith, has accommodation for 600 passengers and about seventy motor cars, and the main particulars are: length overall 283ft; length on load water line, 268ft; breadth moulded at car deck, 48ft; breadth moulded at load water line, 45ft; depth moulded to car deck, 17ft; depth moulded to shelter deck, 26ft; and maximum load draught, 10ft 6in. In the engine-room two British Polar "M.47.M" diesel engines are installed, each having seven cylinders of 340mm diameter by 570mm stroke and developing 1310 b.h.p. at 300 r.p.m. to give the ship a speed of 16 knots. A fuller account of the ship appeared in the October 22, 1954, issue of THE ENGINEER.

William Denny and Brothers, Ltd., completed the twin-screw motor vessel "Arran," which went into service early in the year and was the first of three such ships for the Clyde Shipping Services of British Railways, the other two ships being the "Bute" and "Cowal," built by the Ailsa Shipbuilding Company, Ltd., at Troon. The ships are designed to carry cargo, and about twenty motor cars, accommodation being provided for 450 passengers, and the principal dimensions are: length, 185·6ft overall and 174ft between perpendiculars; breadth moulded, 35ft; depth, 11ft 3in; maximum draught, 7·6ft; and gross tonnage, 567·8 tons. A car lift platform is provided to allow loading at any state of the tide. A speed of 15·5 knots is maintained by two sets of British Polar diesel engines, each having six cylinders of 340mm diameter by 570mm stroke and developing 1100 b.h.p. at 300 r.p.m. Three 60kW diesel-driven generators provide the electrical power for the deck and auxiliary machinery and ship's services. Our illustration gives a general view of the ship, which was described in THE ENGINEER of February 5, 1954.



Motorship "Arran," showing cargo derrick and gap for car platform



Passenger and motor car ferry "Mons Calpe"

OIL TANKERS

As in previous years, more than half the ships constructed during the year were oil tankers, and three such vessels were illustrated in Plate No. 5 which appeared in our issue of January 7th.

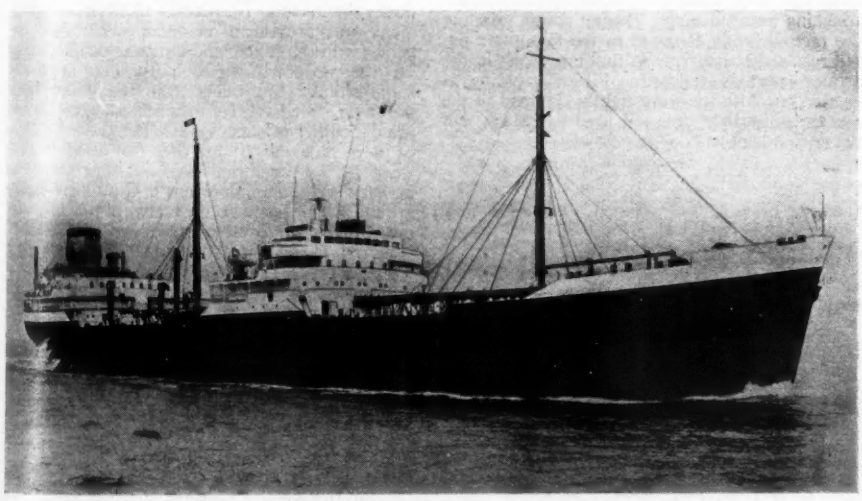
Among the large tankers completed was "World Harmony," built by Vickers-Armstrongs, Ltd., at Walker Naval Yard, for the World Tankers Corporation. The ship has a length between perpendiculars of 635ft, a breadth moulded of 86ft, a depth moulded of 45ft 9in, a draught loaded of 34ft 5in, and a deadweight of 33,000 tons, and will carry crude oil from the Persian Gulf to the United Kingdom. There are ten triple cargo oil tanks and one cargo oil pump room, arranged immediately forward of the machinery space, equipped with three 1000 tons per hour turbine-driven pumps and two 150 tons per hour steam-driven vertical stripping pumps. Parsons Marine Steam Turbine Company, Ltd., constructed the main machinery, which consists of a single set of double-reduction geared turbines of Pametrada design, and developing a service power of 12,500 s.h.p. at 100 r.p.m. of the propeller and a maximum of 13,750 s.h.p. at 103 r.p.m. The h.p. turbine, of impulse design, and the l.p. turbine, of reaction design, work in series and take steam at 850 lb per square inch and 850 deg. Fah. from two Foster-Wheeler "D" pattern water-tube boilers, built by Richardsons, Westgarth and Co., Ltd. All the auxiliary machinery is driven by electric motors and the power is supplied by two 500kW turbine-driven B.T.H. alternators.

The British Tanker Company, Ltd., took delivery from Swan, Hunter and Wigham Richardson, Ltd., of the "British Merchant," which has a length between perpendiculars of 630ft by 85ft 6in breadth moulded by 46ft 8in depth moulded, and a deadweight of 31,750 tons on 35ft draught. There are

thirty cargo oil tanks and one main cargo pump room equipped with three 850 tons per hour turbine-driven centrifugal pumps and three stripping pumps, while two 600kW geared turbo-alternators, one working and one standby, supply the power for the auxiliary machinery. Other electrical requirements are met by one 150kW diesel-driven alternator and a steam-driven 50kW generator. A fully loaded service speed of 14¾ knots is maintained by a single set of double-reduction geared turbines, constructed by the Wallsend Slipway and Engineering Company, Ltd., which develop a maximum of 13,750 s.h.p. at 116 r.p.m. of the propeller and take steam at 450 lb per square inch and 750 deg. Fah. from two Babcock and Wilcox boilers. A sister ship, the "British Engineer," was built and engined by Harland and Wolff, Ltd.

One of the tankers completed by the Furness Shipbuilding Company, Ltd., was the "London Prestige," for London and Overseas Freighters, Ltd., and the ship, which carries a deadweight of 24,600 tons on 32ft 3½in summer draught, has a length overall of 591ft 11in by a breadth moulded of 80ft by 42ft 3in depth moulded. For the oil cargo there are twenty-seven tanks and two pump rooms, each fitted with two steam pumps each of 500 tons per hour capacity, and one stripping pump. Electric power is supplied by two 75kW steam-driven generators and the propelling machinery consists of a N.E.M.-Doxford single-acting, two-stroke oil engine having six cylinders of 670mm diameter by 2320mm combined stroke and developing 6800 b.h.p. at 119 r.p.m. Steam for the auxiliaries is supplied at 150 lb per square inch pressure by one Scotch boiler and a "D" pattern Foster-Wheeler boiler.

During the year, Shell Tankers, Ltd., took delivery of a number of general-purpose tankers, including the "Helcion," built by Swan, Hunter and Wigham Richardson, Ltd., and powered by turbo-electric machinery, of 7500 s.h.p. at 100 r.p.m. in service, constructed by the British Thomson-Houston Company, Ltd. Other ships which joined the Shell fleet were the "Haustrum" and "Haustellum," illustrated herewith, built by Hawthorn Leslie (Shipbuilders), Ltd., and the "Hadra" and "Hadriania," built by Smith's Dock Company, Ltd., all four being engined by Hawthorn Leslie (Engineers), Ltd. The ships have a length overall of 557ft, a length between perpendiculars of 530ft, a breadth moulded of 69ft 3in, a depth moulded of 39ft, and a carrying capacity of about 18,000 tons on a draught of about 29ft 6in. One main pump room, fitted with four 400 tons per hour turbine-driven pumps and two stripping pumps, handles the cargo oil which is carried in thirty-three tanks. The electric generating plant consists of two 550kW geared turbo-alternators and one 200kW diesel-driven alternator, and each ship is propelled at a service speed of 14½ knots by a single set of double-reduction geared turbine machinery, steam being supplied at 500 lb per square inch and 800 deg. Fah. by two Foster-Wheeler boilers.



Geared turbine tanker "Haustellum"

(To be concluded)

Universal Precision Grinding Machine for Bearing Races

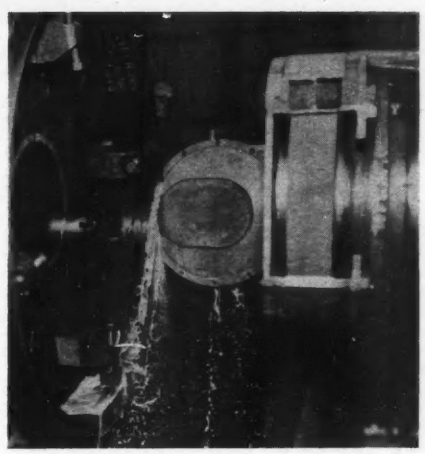
FOR many years the Cooper Roller Bearings Company, Ltd., of King's Lynn, has specialised in the manufacture of split and solid roller bearings with bores up to 55½in, and to meet increasing demands for the very large sizes of these bearings the firm decided some four years ago to install a universal precision grinder which would be capable of producing ball races of more than 100in bore. Inquiries showed that no machine was then available which would satisfy the firm's requirements, and plans were put in hand to design and build such a grinder to its own specifications. This machine was completed some months ago and since then has been in satisfactory service in producing large bearing components to very close tolerances.

The new machine, which weighs 65 tons, is capable of swinging work up to 10ft 6in diameter and 2ft 7in long. It can grind external diameters up to 10ft and face grind 9ft diameter work, the maximum length for external and internal grinding being 2ft. Means are provided for grinding tapers to a maximum angle of 8 deg. as well as special forms such as spherical shapes. The firm states that work carried out to date shows that the machine has an accuracy of 0·0001in in diameter, roundness and parallelism, and that in repetitive working diameters can be ground on successive work pieces to within 0·0001in over the full range of the machine.

The new grinder can be seen in the photograph we reproduce on these pages. It consists of two massive bed-plate castings rigidly coupled together, one casting carrying the wheelhead and the other the workhead on large vee slideways.

The workhead spindle runs in heavy taper roller bearings and is driven by a 27½ h.p. variable-speed motor through a P.I.V. infinitely variable gear and reduction gearing. The final drive to the spindle is taken through multiple vee belts and the range of spindle speeds is infinitely variable between 1·475 and 19·5 r.p.m. This spindle is 14in diameter and it carries a 9ft diameter face plate weighing some 3 tons. An automatic magnetic brake operated by a push button is fitted between the P.I.V. gear and the reduction gearbox in the spindle drive.

The workhead slide has a cross traverse of 5ft 3in along its bed-plate, and its movements for positioning in accordance with the diameter of the work piece are effected through a leadscrew driven by an electric motor. The head can be swivelled on its slide for taper grinding purposes, its rough setting being effected by means of a ¼ h.p. motor and final fine adjustment to precision limits by means of a handwheel. A scale, calibrated in work and wheel diameters for both internal and external grinding, enables the operator to position the workhead slide accurately, ready for grinding.

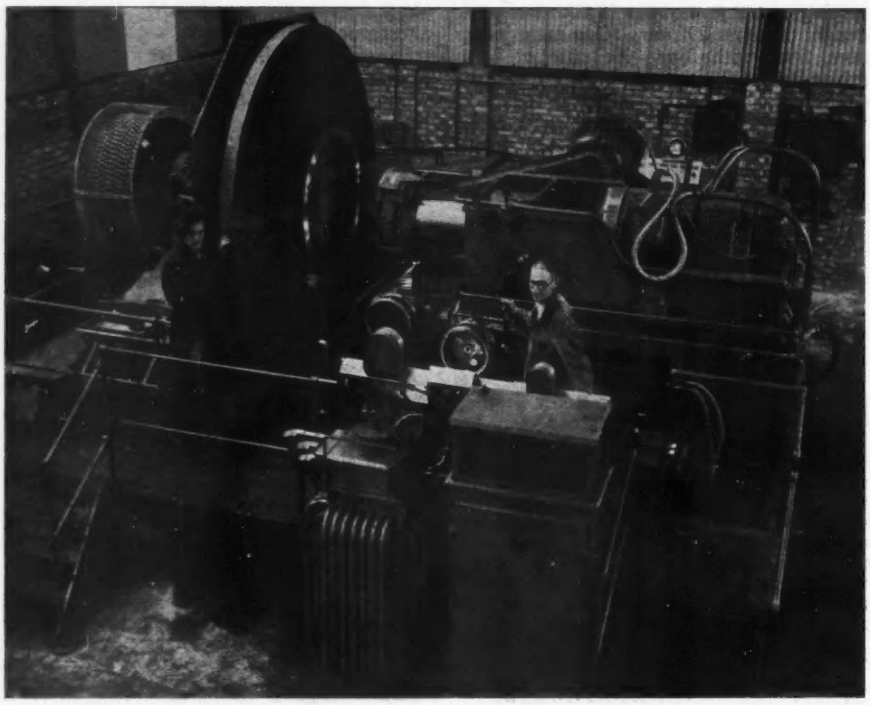


Face grinding a large bearing race. The grinding spindle for internal and external grinding can be seen on the right in the foreground. The operator is controlling the machine from the rear

The wheelhead slide assembly weighs some 18 tons. It carries two grinding spindles, one for internal and external grinding, and the other for face grinding purposes. Its cross traverse is effected by hydraulic rams which operate in conjunction with a fine feed gearbox and leadscrew mechanism for in-feeding during internal and external grinding. These rams are used to position the head initially and then the gripper nut of a handwheel-operated leadscrew is engaged. Thereafter, during the grinding operation, the head is held by a constant hydraulic pressure in contact with the fine feed leadscrew mechanism which acts in the form of a stop. As the leadscrew is turned to apply feed its movement is followed by the head as a result of the pressure applied through the hydraulic system. The same hydraulic ram system is used to reciprocate the wheelhead during face grinding.

The two grinding spindle assemblies are mounted on longitudinal slides on the main wheelhead transverse slide and these spindle slides are also operated by hydraulic rams working in conjunction with fine feed leadscrews in a similar manner. The facing spindle slide has an infeed stroke of 2ft 10in in respect to the work and the internal and external grinding spindle slide a travel of 2ft 7in. These two hydraulic systems are also used for reciprocating the slides during the grinding operation.

The main spindle used for internal and external



Universal precision grinding machine for bearing races. It is capable of swinging work pieces up to 10ft 6in diameter and 2ft 7in long

grinding takes 24in by 6in wheels, and is directly driven by a 40 h.p. variable-speed motor which gives it a speed range from 500 to 1500 r.p.m. The facing spindle is driven through a system of vee belts by a 27 h.p. variable-speed motor. This spindle takes 18in by 3in to 10in by 3in wheels and has a speed range from 750 to 2000 r.p.m.

The hydraulic systems of each of the spindle slides and that of the workhead cross traverse are fitted with regulating valves through which the slide speed can be varied from 1in to 48in per minute.

Whilst grinding is in progress feed increments are made by the operator with reference to dial gauges fitted on special brackets on the slides. These dial gauges are used in conjunction with the master instruments used to measure the work between operations. Because rigidity of the measuring instrument is essential when dealing with large diameters the firm makes its own point gauges, micrometers, &c. Master gauges are made to give multiples of 1in, fractions being added by a micrometer thimble. These master gauges are kept in the coolant tank of the machine to ensure that they maintain an even temperature equal to that of the work. Bores are measured by a point gauge in the vertical position, and outside diameters with a micrometer in the horizontal position. The micrometer is afterwards supported at the same points and in the same plane as for measuring when being checked with the appropriate master gauge. Discrepancies in measurement of work due to individual " feel " are eliminated by application of a trace of Prussian blue or similar marking agent to the workpiece so that the first touch of the micrometer spindle can be readily detected.

All electrical controls on the machine are grouped on duplicate console panels at the back and front of the machine, so that it can be controlled comfortably from either side of the work. The feed handwheels for the longitudinal and transverse slides are also duplicated on each side of the machine. Each console panel is equipped with tachometers indicating work speeds and wheel speeds. The dials of these tachometers are calibrated to read revolutions per minute, peripheral speed of grinding wheel in feet per minute, horsepower rating of motor, corresponding to the revolutions and the equivalent kilowatts input to the motor driving the grinding spindle in use. A kilowatt input meter provides a ready indication of the actual power input to the motor of the grinding spindle used and by comparing this with the reading of kilowatts available on the appropriate tachometer dial, the machine operator can determine how much of the motor power available is being used and thus keep the machine working to maximum capacity. The kilowatt input meter is mounted at the centre of the machine and swivels so that it can be seen from either working position. Adjustable mirrors are conveniently placed so that the machine operator can observe the actual grinding contact.

Particular attention has been paid to ensuring efficient lubrication to the large and heavy moving parts of the machine. All its slideways are automatically lubricated and hand pumps are fitted to allow the introduction of a graphite solution at predetermined intervals. The workhead spindle bearings are grease lubricated and automatic oil lubrication is provided for the swivel and traverse bearings and the leadscrews.

Two pumps of 24 g.p.m. capacity supply the coolant, and one of these pumps feeds the coolant through the spindle and grinding wheel to the work to ensure effective cooling when heavy grinding is in progress. An automatic coolant filtering unit is fitted to clean the coolant before it is recirculated by the pumps.

When the machine is grinding large bearing races the work is carried out in two stages, i.e. roughing and finishing. During rough grinding the race is firmly clamped to the face plate jig, but released at intervals so that any stress in the ground part is relieved. Finish grinding is carried out with the work lightly clamped to the jig, and only light cuts are used to ensure that the part is kept as cool as possible.

WATER REPELLER FOR MASONRY.—Particulars have been issued by Solignum, Ltd., Donnington House, Norfolk Street, London, W.C.2, of a new product it is now marketing which contains silicones and gives a high degree of water repellency to exterior concrete, brickwork, stone, plaster and asbestos above ground level, preventing the passage of water into the pores while still allowing the surface to breathe. Rain and moisture will run off surfaces treated with " Impervion " (silicone) water repeller, as it is known, but it is not, however, suitable for use below ground, where there may be hydrostatic pressure. The repeller is colourless and does not alter the appearance of the surface to which it is applied. It must be applied very liberally to dry surfaces preferably when weather conditions can be expected to remain dry for six hours after application. The solution can be applied on to the surface by brush or spray, and full repellency is obtained after about twenty-four hours. The solution, when dry, is odourless, non-corrosive, non-inflammable and colourless, and it can be painted over if desired.

" Where Do We Go from Here? "*

By W. E. W. PETTER, C.B.E., B.A., F.R.Ae.S.†

In his address at the conclusion of the Aircraft Production Conference, Mr. W. E. W. Petter offered his opinion on the state of the aircraft industry in this country. He considered the three legs on which the industry was based : the customer, the manufacturer and the co-ordinating Government supply organisation. Amongst the points he made concerning policy was the fact that he believed the specification writers had set too high a target and the manufacturers had underestimated the difficulties involved. The industry as a result was overextended. There had been, he emphasised, an attempt to have a little bit of everything, which, he thought, was wrong. The author maintained also that the industry lacked men of executive calibre, and those it did have were not often afforded the right status or one comparable with that in America.

WE have heard much of the improved production technique and methods during these two days. How right it is that we should be searching for new and improved ways of doing things.

One might think that our main problem was to apply our production knowledge. What we know is that in the most advanced fields of aviation generally, and in this country in particular, the real problem is to keep production turning at all and to produce things which can be used when they leave the hangar doors. The real and the biggest problem in British aviation to-day is—so it seems to me—to find how to canalise the work of our limited research, designing and development manpower through the right channels in order that we may have a certain number of producible aeroplanes, in the various classes, which meet our essential needs at the right time. It is this problem which must be solved, if we are to go anywhere from here, with which I will try to deal briefly to-day.

Our air effort as at present constituted rests upon three supports, the customer who must frame the requirements, an industry which must fulfil them, and a supply organisation which must co-ordinate the two. Any lack of effectiveness in any of the three essential legs of the tripod on which we build will immediately show itself in the outcome of our efforts. It is because there have been weaknesses in each that our air situation is far from satisfactory to-day. I shall try to indicate what, in my opinion, are these weaknesses and to suggest how some of them might be eliminated.

Everything starts with the customer requirement, so we will consider these first.

The framing of requirements, especially in the military field, is a duty of appalling responsibility. If over-ambitious, the problems set to the designer will be of such complexity that he will either not achieve production at all or be so late as to be obsolete. If too easy, we might be faced one day with an enemy, or competitor, possessing technical superiority.

The specification writers since the war have, in my opinion, tended to set their sights much too high ; they have aimed too far ahead—and no doubt the industry (in which I include the equipment and armament manufacturers who, together with the engine and airframe people, make up the weapon system) must take a grave responsibility for being too ready in their promises. We have, for instance, underestimated the difficulties of supersonic flight, the time scale of new radar sets, the time to develop new weapons. A somewhat doubtful time scale has perhaps seemed unimportant in a political background which seems to have always put any war possibility a comfortable four to five years ahead !

As Ed. Heinemann, chief engineer of Douglas, Santa Monica (who has made a great contribution to the simplification and lightening of high-performance aircraft) so truly said recently, in a paper presented to the Society of Automotive Engineers : " A specification must consider not what is possible, desirable and necessary, but also what is practical either now or in the near future." And again, apropos the appalling increase of size, complexity and weight which is occurring on both sides of the Atlantic, but which we can afford much less than the U.S.A., he said : " The

* Third Annual Aircraft Production Conference, Southampton, January 14 and 15, 1955.

† Managing director, Folland Aircraft, Ltd.

importance of weight can be expressed in a few words—excess weight is accompanied by inferior performance, disproportionately higher cost and decreased reliability." I do not in the military field yet detect any significant signs of a return to realism.

On the industrial side our gravest fault has been, I think, over-commitment—too many channels for too little water. Designing and developing an aeroplane to-day is a tremendous undertaking and it needs the almost undivided attention of whoever in the firm is the chief design executive, together with all his staff, for a period of five to six years—three, perhaps, for the project work and the design and building of the prototypes, and three thereafter to make them work in association with the customer, and to incorporate such modifications as are needed for production. The number of men who combine the qualities of leadership, inventiveness and diplomacy with those of character necessary for the top design job certainly appear to be no more than the number of approved aircraft firms to-day ; apart from the leaders there are hardly sufficient sound lieutenants, the people who really do much of the work, to go round even the good existing teams, and the same is found even more acutely at the level of designers and technicians.

If you accept my " six-year " hypothesis, one only has to do a little arithmetic to see how few good new aeroplanes Britain can really produce in, say, ten years, and this has to cover the full range of bomber, fighter, large and small civil aircraft, helicopters, naval machines of various types. The facts would seem to confirm the arithmetic. Yet to take only one example—we see about twice as many machines in the largest class, military and civil, being attempted as I would judge the country can manage if it is to get its aircraft in the right time, adequately developed, while leaving sufficient manpower over for other essential types. We have many examples in aeronautical history where even the strongest firms have fallen short technically or in time, by trying to follow one big success with another immediate major effort—but it unfortunately takes an unusually strong-minded firm and designer to decline an interesting new prototype order. So that the cure for this particular ill must be sought mainly in official quarters. Technical over-commitment is one of the scourges of our profession.

To the question recently so pertinently raised by your president the other day—" whether . . . we can afford to make a very little of everything which is all that present costs and budgets allow . . ." I for one would return an emphatic " We can't."

In this matter you production people can help considerably, and I don't mean only directly. There is a tendency for factory management to seek expansion at all costs and so to demand an ever-increasing flow of prototypes that with due allowance for failure there shall always be assured large production work. This is the dance of death for the designers. Less new endeavours, fully and lovingly completed, would certainly ensure more, not fewer, production successes.

The wider use of sub-contracting within the industry is one answer to the production problem; another is that the production people themselves should be encouraged to help more in the development stages, and it is astonishing how much help a willing aircraft production team can give. If we were less over-committed, more would be foreseen and there would be less modification, but nevertheless a far more sympathetic attitude to important modifications by most production people would be of inestimable help not only to the designers, but to the country.

Indeed, I would say that it would be better to forget all about new techniques such as skin-milling until we have caught up with and passed the lamentable state of affairs which are sometimes heard of when machines, urgently needed, go straight from the factory, not to the Services, but for weeks or months to Service modification units.

A new major aircraft only every six years is not, perhaps, calculated altogether to satisfy the younger technical and project designers. The solution is probably to sandwich in research design and flight work, of which a vast amount needs to be done and for which contracts can usually be obtained, choosing a subject which accords with the firm's interests and future aspirations.

Another weakness in the industrial leg of our tripod is due to unbalanced organisation ; too much emphasis being often given to the production and commercial side and a quite inadequate weight to engineering. The top engineering executive should be, as he is in America, in name and in fact, at least a vice-president engineering. There is still, in some firms, a tendency, out of all keeping with his outside responsibilities and the internal leadership and power of decision which he must exercise, at times even on matters vitally affecting production, to regard the design head as a " back room boy " to be brought out only on gala occasions. In an industry in which engineering touches every aspect of activity, this is plainly disastrous.

Our best firms—and these include those who have delivered most of the goods—are not organised in this way, but some still are, and in these there is inevitably a degree of wasted ability and enthusiasm which we simply cannot afford, while in the nature of things good work will not come out.

There is, however, a third and vital element in the aviation scene, if a properly organised industry and reasonable customer are between them to get the answer ; I refer to the Supply and Production Ministry, which correlates the two. This has powers for good or ill which have not always been realised, or well exercised. It should be, and at its best has been, a sound balancing force, watchful to prevent excess and wasted effort between the over-enthusiasm of the Service specification writers, whose assumptions, and those of the scientists who advise them, must be independently examined, while also on guard that particular and general commitments in firms and in the country as a whole, are such that the best possible use is being made of our manpower and that no more is being attempted than can be brought to fruition in a satisfactory condition and time.

The Supply Department has the power of handing out the rewards and " pains " of good or bad industrial performance, and I believe it will only do good if rewards and pains could be magnified. Just as there have been times when the Supply Ministry has helped to keep going machines that have subsequently proved to be of vital worth, such as the " Mosquito " and the " Viscount," when the would-be user had temporarily lost interest, so there have been times when, since the war, this essential balancing force seems to have become ineffective and I think that many of our present difficulties can be attributed to that.

In peace time there is a temptation for the Ministries to be increasingly absorbed in the framing and enforcement of requirements. While some requirements are necessary, we designers often cast envious eyes at the army of talent in the Ministries dealing with them, particularly when contemplating our small resources of men with which we must wrestle, not only with Nature, but with the bureaucracy as well. Somehow we ought to secure a double advantage by getting half of them to desert to us !

The true role of the people concerned with aircraft supply, under whatever name they may function is, of course, much wider than this and there are signs that this is being again realised. I am glad to note, in particular, that a policy of shorter steps now seems to be finding favour. If one is aiming seven years ahead, the problem postulated is such that the chances of success on each of the airframe, weapon and guidance equipment is probably no more than 1 : 2. Taking all together, therefore, there is a 1 : 8 chance of success, further reduced by any power plant disappointments. A 1 : 8 chance which, in fact, probably takes ten years, is not good enough, but it is no use blaming only the aircraft designers. Now, if a target of only four to five years is taken, the chances on the aircraft, weapon and guidance should be at least 3 : 4 each, so that the overall project should have something better than a 27 : 64, or, say, 1 : 2 chance. What is much more, it is likely to be on or near time ; it is less liable to policy changes which might render it useless, and the shorter time scale makes it easier to anticipate any changes or switching which may be required in the event of a partial failure of any of the component parts of our weapon system. At any rate, the chances of success in time—and there is no other success in aviation—is about four times as good in the short step as in the long. In fact, in this way your people should get something to produce. We must hope that the suppliers will be able to convince the users of the rightness of short steps—indeed, we must help them to do so.

In times of difficulty it is easy to turn to the short-cut palliatives or cure-alls, and no doubt we shall be hearing of the advantages of nationalisation or large-scale rationalisation. In my view, neither offers any hope whatever of a solution.

For their correct functioning and mutual interaction, the three complementary supports of our air effort must be independent administratively. I can see nothing but ossification arising from the attempt to put the three under one roof, as would occur under nationalisation. It is bad enough now, when, like all human institutions, one of the three legs of our organisational stool becomes wobbly—as was seen during the early '30s, when an impoverished industry was increasingly wrapped up in biplanes and red tape by the users—who seemed to have forgotten they might have to fight a war, and the Supply Ministry—who wished to produce aircraft of excessive versatility. An escape was only made to monoplanes and sanity at the beginning of the Rearmament Programme, with some prodding from such brilliant and unconventional efforts as the Hawker " Hart " and the Vickers " Wellesley."

There are, correspondingly, dangers in the too close association of any of the three partners, to the detriment of the third. The solution of industrial rationalisation is superficially more attractive and for big machines requiring large resources of men and research equipment sizable units are undoubtedly necessary.

For the smaller military and civil aircraft, I believe the best results can be obtained from units whose technical and design staffs, excluding the experimental shops, probably consist of between 100 and 200, since larger numbers than this cannot be beneficially employed on even the complex smaller aircraft. There will be, undoubtedly, a very much greater degree of enthusiasm and energy shown if the team forms part of an independent aircraft organisation and these qualities are also more easily fostered in the medium or small firm than the very large one.

For the design team to be of any use, its firm must be a producer and tooler up of aircraft, since a large proportion of the time put into the design has got to be in the creation of light, simple and easily produced detail, and this art will be quickly forgotten by those no longer associated with production.

Personally, therefore, I believe that we should at all costs eschew leaps into reorganisation of whatever political hue, but rather put our faith in the three-legged stool, suitably stiffened up, of the interacting user/manufacturer/Supply Ministry—arranging so far as possible that each is effective and on top of his job, and is imbued with the essential qualities of common sense, honesty, energy and courage. When we are battling with such odds and all have so much to learn, nothing less will do.

I am aware that some of what I have said may be regarded as controversial, but perhaps this does not come amiss at this time. Further, I am but returning the compliment of your president, who recently lectured very ably to the Royal Aeronautical Society on " Where Goes the Aircraft Industry ? " You will see, however, that on one point I disagree with him fundamentally in his view that the biggest problem before us is to get production going. I would rather say that our biggest problem is to provide the conditions in which design and development can prosper.

It is the small pool of technological manpower, to be found in our drawing and technical offices, our experimental test and flight organisations, and certainly, too, in sections of our Government establishments, which is our creative source. Many years will go by before education and experience will swell the numbers to meet the needs. Meanwhile, production can only start where these people taper off.

Cutting Tool Research Laboratory

A NEW research laboratory has been opened by Firth Brown Tools, Ltd., Sheffield, for the study of all aspects of tool manufacture from control analyses on raw materials to the final testing of cutting capabilities. This firm makes all kinds of engineers' cutting tools including drills, saws, milling cutters, taps, files, tipped tools, &c., as well as large numbers of special tools and cutters. It was formed in 1946 from the engineers' tools departments of Thomas Firth and John Brown, and at that time a problem arose with regard to facilities for metallurgical work involved in the development and testing of tools. Facilities were then provided by the Brown-Firth research laboratories, but a need steadily grew for a separate research organisation, and it was finally decided last year to set up the department which has now been opened adjoining the works.

The new laboratory is situated in an existing building which has been extensively rebuilt and equipped with services to suit it for research and provided with air conditioning to give the necessary standard of cleanliness required. Eventually the new research department will comprise eight individual main laboratories, together with offices and covering an area of some 7000 square feet. These laboratories have been equipped with a wide range of modern apparatus for all forms of research into tools and their materials, as well as for investigating new cutting tools and methods of machining.

The main piece of equipment in the metallographical laboratory, which is principally concerned with the examination of the microstructures of tool steels, hard metals and hard abrasive compounds, is a Vickers projection microscope. This instrument is used for the visual examination and preparation of photomicrographs, and the other microscopes provided include low and medium power binocular microscopes for the micro examination of cutting tool specimens. The usual apparatus for the preparation of specimens for micro examination is installed together with modified equipment suitable for grinding, lapping and polishing with graded diamond dust. This equipment is a necessary provision, since most of the specimens examined are extremely hard and cannot be polished with other polishing media.

Provision is made for the etching of specimens prior to examination, but this is often replaced by "heat tinting." Heat tinting is a process applied by Firth Brown Tools, Ltd., for the micro examination of hard metals of the multi-carbide type. It has the advantage that with careful control it colours the various carbides in different ways and enables each type of carbide to be readily identified on subsequent micro examination.

The chemical section of the analytical laboratory is equipped to deal with the analysis of raw materials to ensure that they are within the specifications laid down, and with intermediate and final products as a check on production processes. An example of this laboratory's work is in the analytical work connected with "Mitia" hard metal manufacture, which involves analyses on wolfram ore, intermediate products such as ammonium paratungstate and tungsten metal, alloy powders containing tungsten carbide, titanium carbide, tantalum carbide and cobalt, as well as the final hard metal. Analyses ensure not only the control of harmful impurities, but also the correct proportions of the constituent elements.

The analytical determinations required are in many cases difficult to carry out because of the unusual constituents which are used in modern tool materials. A particular aspect of this analytical work is the determination of trace elements which can have a marked effect on cutting tool performance. In this connection a flame photometer has been installed for the rapid determination of sodium and calcium present in small amounts in the tungsten compounds used.

The question of trace elements is one which can frequently best be determined by spectrographic analysis, and a special spectrographical laboratory has been established. This laboratory is equipped with a Hilger automatic large quartz spectrograph, and the ancillary equipment for use with it includes that for the provision of light sources of the arc and spark type, motor-driven microphotometers and a spectrum comparator.

The laboratory for the mechanical testing of tool materials has amongst its equipment a 5-ton Avery tensile testing machine, a Firth Brown Tools variable load "Hardometer" and a Vickers hardness testing machine. The equipment in this particular laboratory is limited, since most of the mechanical testing of tool materials involves the use of machine tools and these are housed in other laboratories.

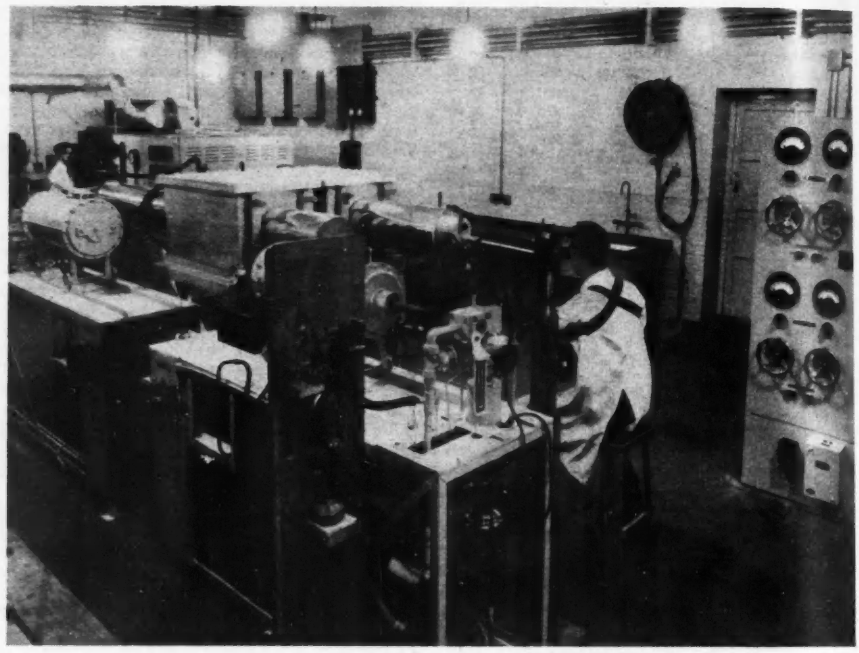
A heat-treatment laboratory, one corner of which can be seen in the accompanying illustration, has been equipped to carry out under carefully controlled conditions any heat-treatment work involved in tool manufacture. Provision for this class of investigation has been made by the installation of high-temperature controlled atmosphere furnaces, which will operate at temperatures as high as 1650 deg. Cent., together with vacuum furnaces which will operate up to 1400 deg. Cent. with a vacuum of 0·001mm mercury absolute pressure. Small salt bath furnaces are installed for the heat-treatment of carbon, low alloy, and high-speed steels, together with small tempering furnaces to enable development work to be carried out on the large range of "Speedicut" tools made by the company from these materials. A 30kW high-frequency furnace working on frequencies of 175–200 kc/s is to be used in connection with experiments on heat-treatment of tool steels, brazing of tool assemblies and on the preparation of tool materials by a modification of the powder metallurgy process known as hot pressing.

This heat-treatment laboratory is also concerned with the development of certain aspects of the heat-treatment furnaces themselves, particularly furnaces for the manufacture of tool materials by powder metallurgy processes.

The work of the physical laboratory is largely concerned with the determination of the grain size of the considerable number of powders which are handled by the hard metal division of the company. In this work the particle sizes of the powders cover a wide range, some have to be accurately sized in the range of 8–20 mesh, whilst the finest powders are controlled to a grain size of less than 0·001mm. To cover these requirements apparatus has been installed to enable a number of different methods of grain size measurement to be employed. These methods include sieving, microscopic measurement and counting, turbimeter and Spekker light extinction methods, air permeability, and water elutriation. There is also apparatus for the examination of the magnetic and electrical properties of tool steels and hard metals, and it is being used to determine how far these properties can be used for the inspection and control of the finished product.

As the control of temperature is an important factor in the manufacture of small tools, a pyrometrical laboratory has been equipped for the standardisation of all types of temperature measuring equipment, including optical pyrometers. In this department provision is made for the manufacture of thermocouples as required and for instrument repair work.

An experimental machine shop at present under construction is to be provided primarily to enable test specimens to be prepared. Due to the hard character of many of the materials which are handled, unusual methods of machining test specimens are required, and the equipment being installed includes that for machining by the "quenched arc" or "spark discharge" process. An "Erodomatic" machine is capable of cutting or drilling holes of any form in the hardest tool materials, and an "Erodosharp" tool sharpening machine is also provided. A cutting-off machine also working on the spark discharge process built by Firth Brown Tools, Ltd., has also been installed. These new methods of machining will not only facilitate production of test specimens in hard material in forms which cannot be produced by any other method, but they will make possible development work on the application of these new cutting methods to production problems in the preparation of special tools.



Part of the heat-treatment laboratory showing vacuum and controlled atmosphere sintering furnaces

The research facilities of the company include two laboratories dealing with the cutting action of finished tools. One of these, a high-speed test lathe laboratory, is equipped with a large Swift test lathe, which was installed for this purpose by the company some years ago. This lathe is capable of operating at speeds from 18 to 1500 r.p.m. and absorbing up to 90 h.p., and it will take test bars 20in diameter by 9ft long. The laboratory contains the necessary equipment for the correct measurement of tool form and also equipment for measuring the wear which occurs on the "Mitia" hard metal tools during test.

The second laboratory is equipped for testing drills, taps, saws, &c., and is at present under reconstruction.

Fork Lift Truck with a Slewing Mast

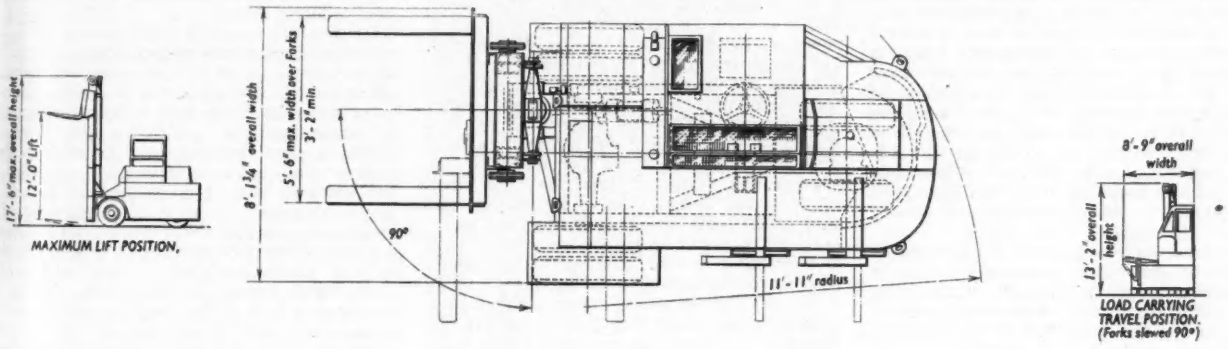
A new design of heavy duty fork lift truck which is now being made by Ransomes and Rapier, Ltd., is fitted with a slewing mast to facilitate the handling of long loads in narrow gangways in stockyards by enabling the load to be carried in line with the direction of travel of the truck. This truck has a turning radius of 12ft and lifts loads of 12,000 lb at 24in from the face of the forks.

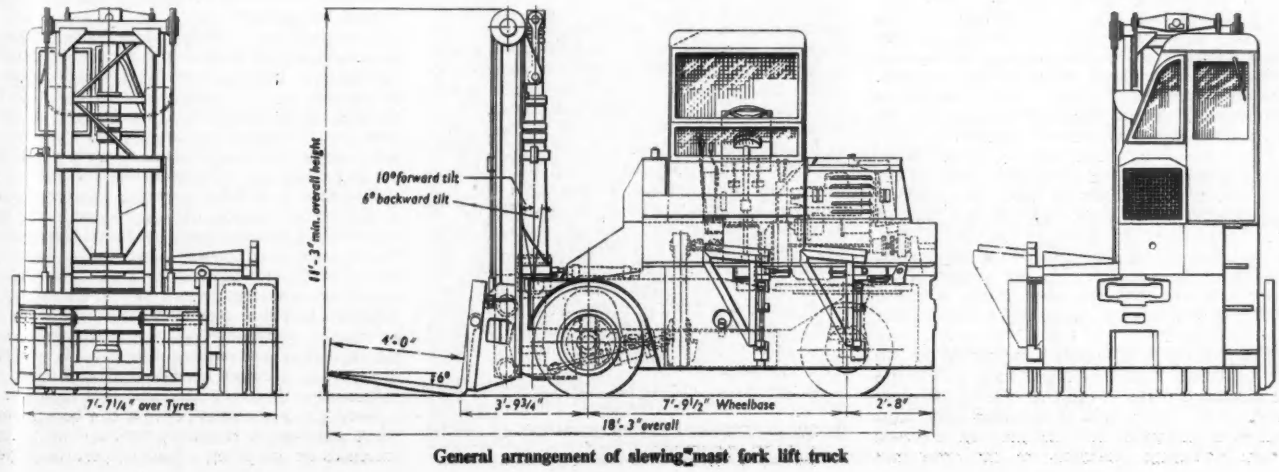
A FORK lift truck fitted with a slewing mast has been developed by Ransomes and Rapier, Ltd., of Ipswich, for handling long loads in confined spaces. This truck can be used to advantage in stockyards where timber, poles, rails, pipes, steel sections, &c., are stored in a series of stacks, or sets, as they are called, arranged end to end and running back to some depth from the sides of comparatively narrow gangways. In such cases the stacks to the full depth of a set, and those at the rear of a transverse path to the back of a depleted set, can be handled without disturbing the stacks in adjoining sets. The truck is driven into the required set with its forks in their forward position and a load from a stack raised in the usual way. The truck is then backed out from the stack and by combining the mast slewing and the steering movements when it reaches the main gangway, the load can be aligned with the axis of the machine and supported along its side for transport lengthwise along a narrow road. The slewing mast also makes easy the negotiation of sharp corners when transporting long loads, as the load can be raised and turned independently as required, whilst the operator is steering the truck. The truck, which has a turning radius of 12ft, is designed to lift loads of 12,000 lb at 24in from face of forks and it has a standard lift height of 12ft 6in. In full working order it weighs just over 10 tons.

The general design of the new truck and its method of operation can be followed with reference to the drawing and photograph we reproduce. It will be seen that the mast assembly is offset to one side and this assembly can be rotated through 90 deg. to align long loads supported in the forks on the opposite side of the truck. In the sequence of operations, after a load has been raised and the truck manœuvred to the travelling position, the mast is turned sideways, the forks then being lowered until the load rests and is partly supported on brackets at the side of the machine. With a long load thus supported it can be safely transported without danger of unbalancing and falling off the forks. The load on the hydraulic system is also proportionately reduced, although it is fully effective should it be required to raise and turn the load to negotiate sharp corners. The load carrying brackets at the side of the machine are pivoted and can be set back against the chassis when the truck is used for normal fork lift operations.

The machine has a heavy fabricated steel plate frame which provides a rigid chassis assembly with the bedplate for the engine and

12,000 lb capacity fork lift truck with forks turned through 90 deg. to support load in transport position on brackets at the side of the machine for movement along narrow gangways





General arrangement of slewing mast fork lift truck

machinery. The power unit is a Perkins oil engine rated at 70 b.h.p. at 2000 r.p.m., and the drive is transmitted through a Borg and Beck 14in dry plate clutch to a gearbox. This gearbox gives three speeds of 4, 8½ and 20 m.p.h. in both forward and reverse travelling directions. A triple roller chain is used to transmit a further reduction drive to the "Eaton" front axle of the machine. The hubs and differential are carried in large taper roller bearings. The detachable steel disc wheels on the front of the machine are fitted with twin metallic reinforced pneumatic tyres and in addition to pedal operated internal expanding hydraulic brakes an independent hand brake is provided.

The front end of the machine is carried by a twin wheel castor through which it is steered. The steering wheel is connected through a bevel gearbox and universal shaft to a worm which actuates a worm wheel fitted to the top of the castor kingpost. A supplementary form of self-steering is fitted to give effortless control and rapid manœuvring in confined spaces at low travelling speeds. This self-steering mechanism is put into effect when a control lever in the driver's cab is moved to apply the hydraulic brake on one or other of the two castor wheels. When the brake on one wheel is applied the castor pivots on the other wheel as the truck moves, and thus automatically reduces the effort required in turning the steering wheel.

A hydraulic pump of ample capacity is driven from the front of the engine through a torsional vibration damper and multiple vee belts. The control valve for the hydraulic system has a spring return to the neutral position when the pump is unloaded, and a built-in pressure release valve protects the system from overloading.

The massive hydraulic elevating cylinder which supports the mast assembly also forms the centre post for the slewing motion. It is carried in a bushed journal and ball thrust bearing in a heavy trunnion bracket on the main frame of the machine. This single acting cylinder has a 5½in diameter piston and gives a fork elevating speed of 35ft per minute, the lowering speed being automatically controlled at 60ft per minute irrespective of the load on the forks.

The inner main mast of heavy welded plate construction is made in two sections, the lower one of which extends to just above the level of the trunnion support bracket and the chassis of the truck. This lower mast section is non-rotatably attached through its cross members to the main cylinder, whilst the upper section is rotatably supported in brackets on the upper part of the cylinder. Through brackets at its base the mast is linked to the piston of a double-acting hydraulic cylinder which is designed to tilt the mast assembly up to 10 deg. forwards and 6 deg. backwards. At its foot one side of the rotatable upper section of this inner mast is connected to a double-acting hydraulic slewing cylinder.

The outer mast, which carries the fork trolley assembly, is supported in machined paths in the channel-section vertical members of the inner mast through large diameter load rollers mounted on ball and roller bearings. At its head this mast is connected by links to a crosshead at the top of the hoisting cylinder piston. These links allow a restricted amount of movement when the mast is being raised or lowered to compensate for any slight slack between the support rollers and the inner mast guide channels. The introduction of these links prevents the transmission of any bending moments to the hydraulic elevating piston and cylinder.

When the outer mast with its fork trolley assembly is elevated on the upper section of the inner mast, and is clear of fixed lower section and chassis of the truck, the slewing cylinder can be actuated to slew it through 90 deg. to the left, and align the load on the forks along the side of the machine. The load rollers of the outer mast are spaced in two groups to give a wide distribution of the load on the main inner mast members.

The fork trolley assembly is supported on two sets of rollers at each side and these rollers run on machined paths in the channels of the outer mast. The trolley hoist rope passes over large pulleys at the top of the outer mast and is reeved round equalising quadrants on the upper part of the inner mast. The use of these quadrants, which are pivoted to move a small amount, ensures that both falls of the hoist rope are equally loaded even when a load is offset on the forks. The forks are freely hinged on single pins on the trolley frame and their spacing can be adjusted from 32in to 60in centres in accordance with load requirements.

A series of interlocks is actuated by a lever system and controlled through a single hand-lever from the driver's cab. The interlocks prevent the tilting and slewing motions being operated together, and ensure that the slewing motion cannot be operated until the mast and trolley have been raised sufficiently to clear the chassis. Slewing can only take place when the mast is in the vertical position, and the interlocks ensure that the rotating and non-rotating sections of the inner mast are correctly aligned when the outer mast assembly is in the lower position.

It will be seen from the illustrations that the driver's cab is arranged in an elevated position on one side of the truck. In this cab the driver faces the load-carrying side of the truck and from this position he has a clear view forward and backward and of the long loads at the side of the machine during manipulation and transit.

Economics of Intensified Use of Railway Operating and Motive Power Resources

By H. H. PHILLIPS, O.B.E., M.Inst.T.*

A note in last week's issue summarised a paper presented before the Institute of Transport on January 10th. It opened by showing that statistically locomotives are in payload movement for less than seven hours a day; drivers spend only about five hours a day on the footplate of an engine in traffic; wagons carry loads in train movement for less than fifty-five minutes a day; and passenger train stock is attached to a train engine for not more than 4½ hours a day. We print here extracts from the remainder of the paper in which possibilities of improved utilisation are reviewed.

Possibilities of Improved Utilisation

Locomotives.—It has been stated that the locomotive spends two-thirds of its life in motive power depots and repair shops. This is not wholly due to the requirements of the motive power or mechanical engineering departments. The employment of locomotives is mainly governed by the requirements of the passenger and freight time-tables and these are complex and exacting. The staff responsible for diagramming the working of locomotives must have regard to the speed demanded by the schedule, the weight of train, the route availability of the various types of locomotives and must at the same time bear in mind the return workings necessary to get the locomotives back to their home depots. During the last twenty years or so considerable attention has been paid to the possibility of getting more work from each locomotive and where this could be achieved by replacing a simple out-and-back roster by a triangular working or a sequence of more complex journeys this type of planning, frequently referred to as cyclic diagramming, has been adopted. The construction of a greater proportion of locomotives suitable for both passenger and freight train working has facilitated planning and contributed to the better results achieved. As a result of these efforts the British Railways fleet of locomotives has been progressively reduced. But after paying tribute to the skill and ingenuity which has been applied to this task, the fact remains that there are many locomotives not so fully employed as they could be and it is when this spare availability is brought into use that economies accrue. This generally involves the replanning of work, and whilst much has been done in this direction, I believe there is still scope to do much more. Perhaps you will permit me to draw on my own experience to illustrate what I have in mind.

At one period during the war, congestion was arising in a certain area due to a shortage of freight locomotives. In an endeavour to relieve this, another district, employing similar locomotives for mineral traffic, made an examination of all services worked by locomotives manned for one turn of duty only, in order to see to what extent adjustments in the schedules could be made so as to permit of more two-turn working being diagrammed. After a careful study it was found possible to retime some services to run a little earlier and others a little later, thereby removing overlapping demands for power, with the result that about fifteen locomotives were released for use elsewhere. There, relatively small adjustments, while yielding a worthwhile economy, did not prejudice the service to the customer.

This is an example of taking advantage of the availability of locomotives which would otherwise be standing idle in the sheds. One of the difficulties in the way of using these periods of spare availability is that they are sometimes not quite long enough to cover jobs for which they could otherwise be used. It should not be assumed that, because the present availability is not being fully used, there is nothing to be gained by extending it. I believe there would be much greater scope for the kind of action I have just mentioned if the availability of the locomotive could be slightly increased. This implies a reduction in the time occupied in servicing and minor repairs in motive power depots. It is, of course, right to say that in the design of the most modern locomotives a good deal of thought has been given to the possibility of facilitating servicing and repairs. For example, the fitting of rocking fire grates, hopper ashpans, and self-cleaning smokeboxes lightens the work of servicing, and the greater accessibility of parts makes repair easier, but I wonder if sufficient study has been given to all the possibilities of mechanical aids at the depots. The mechanisation and replanning of a large motive power depot is, of course, an expensive business. It may involve a very heavy expenditure which could not be financially justified solely by the savings to be achieved through a reduction in servicing costs. If, however, as a result of improved methods, the time required for servicing each locomotive could be reduced, say, by one hour, the acceleration in the rate at which locomotives could be passed through depots having a large allocation of train engines would, I believe, make it possible to achieve a saving in the number of locomotives required and might tip the scales in justification of the cost.

As to major repairs and overhauls, it is probably not generally realised that the ratio of engine-hours in traffic to hours under or awaiting repair is of the order of 2 : 1. The engine-hours in traffic average eight hours a day; the time off for repairs averages four hours a day. I would hazard a guess that a good proportion of the latter period is not devoted to actual repair work but to waiting of one kind or another. A reduction in these periods of waiting might involve some increase in the cost of repairs, but I suggest it would be worth considering to what extent the value of greater availability would justify additional repair costs. At the present time it is necessary to have at least one spare locomotive for each five in service and even a modest shortening of the repair and waiting period would open the way to a substantial saving in the number of engines required.

Passenger Trains.—It would no doubt generally be admitted that most of the existing passenger services were designed to fit in with what was believed to be the public demand and that in drawing up the time-tables, operating considerations were relegated to second place. As a result many services are extremely expensive owing to the low utilisation of locomotives and carriages.

The need to reduce operating expenses needs no argument; indeed, rising costs and increasing competition make it imperative, and it is my view that one way to effect very substantial savings lies in a re-planning of services with greater regard to operating considerations. It should not be imagined that this approach necessarily leads to an inferior standard of service; experience has shown that in certain circumstances it is possible to provide a better service and still effect a reduction in the equipment and staff required.

Some good examples of what can be achieved when passenger services are reviewed with more emphasis on operating considerations were given

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in the *British Transport Review* for April, 1954 ("Towards Fuller Employment : Passenger Rolling Stock," by G. F. Fiennes). The first case quoted was an experiment in replanning in South Wales. It will be realised that the job of replanning a network of services is not one which those concerned with day-to-day working can take in their stride. Consequently a small body of experts was appointed to examine the suburban services running on the lines radiating north and west from Cardiff (covering about 200 route miles) and to explore the possibility of introducing regular interval services which would be more attractive to the public and yet at the same time enable a reduction to be made in men and rolling stock. After careful study extending over some months, new time-tables were produced which gave greatly improved services on a regular interval pattern, the increase in the number of trains being as much as twenty-three a day between Cardiff and Barry and fourteen a day on the Cardiff-Pontypridd section. Although these alterations involved an increase in train miles of over 6500 a week, the number of locomotives required was reduced by twenty-five, passenger coaches were reduced by ninety-eight and the number of staff required by fifty. The overall result of this exercise in greater utilisation was to reduce the operating costs by more than 20 per cent. But the benefit has not stopped there. The better services have attracted more business and consequently the net revenue position has been further improved.

The extremely satisfactory results arising from this study led to similar investigations being instituted in other areas of the Western Region. The completion of these, which are all concerned with suburban or local services, will take some time but it is worth mentioning that in every case which has so far been brought to finality economies have been secured from this new approach.

The second of the examples given in *British Transport Review* relates to a main line express passenger service in East Anglia. I cannot do better than repeat the author's own words :—

"The express service . . . was introduced between Liverpool Street and Norwich by two routes : via Ipswich in 1950 and via Cambridge in 1953. Although far from South Wales in point of geography, administration and thought, the principles of . . . (intensified use) applied. Added to those principles, however, was the value of a modest acceleration . . . In this case accelerations ranged from ten to thirty minutes in order to enable the engines which come into service early in the day to run two round trips between Liverpool Street and Norwich, covering 464 miles in all . . . or nearly four times the national average. Since the engines which were working the service before 1950 were not capable of the accelerations required, it was necessary to order a new type. Included in the estimates for this scheme, therefore, was the cost of twenty-three British Railways standard '7MT' locomotives ; of this total one-third represented the betterment involved in the higher performance. This betterment cost was recovered in fifteen months. The principal economies in the 1950 and 1953 schemes together amounted to ten engines, fourteen train crews and thirty-six carriages."

These illustrations of what has been achieved in widely contrasting circumstances will no doubt be sufficient to support the belief that nothing but good would come from a wholesale overhaul of the existing time-tables. The present is undoubtedly the time for action, particularly so far as local services are concerned. The British Transport Commission has announced its intention to embark upon a large scale development of diesel multiple-unit trains which will result in a more widespread use of this type of service than obtains on any other railway system in the world. These diesel units have many attractive features, not the least of which is their greater availability, and if the maximum economies are to be secured, it is essential that operating considerations should be allowed to have a high place in the replanning of the services upon which they will be introduced.

It has been stated that British Railways are also considering the use of diesel traction for main line traffic. If it is decided to employ diesel locomotives on a large scale the problem of finding sufficient work to take full advantage of their greater availability will be a formidable one. But it is a problem that must be solved if the economies which diesel traction offers are to be secured. Such a development would add further emphasis to the case for overhauling the existing time-tables ; indeed, it might be a compelling reason. In any examination of services which may be undertaken, it will probably be found that in many cases the most advantageous planning will depend upon some acceleration of the present schedules. This could be achieved in two ways ; by the provision of greater power in the locomotive (which was the only way immediately open to the Eastern Region when it remodelled the Norwich-London services to which I have already referred), or by reducing the gross weight of the train. The second alternative would involve the construction of lighter passenger stock with a better capacity-to-tare ratio and is therefore a longer term solution, but it is obviously the one which would eventually pay the best dividend.

Freight Stock.—The present position is that, on average, freight wagons make about thirty-three loaded journeys a year—say one every ten days. The operations embraced within this period include : (1) loading at starting point ; (2) the loaded journey ; (3) shunting and marshalling ; (4) unloading at destination or tranship point ; (5) transfer when empty to the point of reloading ; (6) under or awaiting repair, and (7) standing idle when supply exceeds demand. Of these seven components the actual train journey accounts for the least time, namely, about eight and a half hours. The Commission pointed out in its last annual report that before running speeds can be materially improved it will be necessary to change from the traditional method of operating the majority of freight trains with loose couplings and hand brakes to a more rigid coupling and continuous power brakes. Experiments are in hand to evolve the best design for adoption as standard on British Railways. An increase in the proportion of power-braked wagons would not only reduce the journey time but would enable freight trains to be timed to take advantage of margins between passenger trains to a much greater extent than is now possible. While these accelerations would undoubtedly contribute to the better utilisation of stock, improvements must also be sought in other directions if the economies which would come from using a smaller fleet of wagons more intensively are to be obtained.

Since the railways were unified, considerable thought has been given to the possibility of re-routing trains in order to reduce intermediate shunting and remarshalling, and much progress has been made. But a good deal of marshalling will always be necessary and it is therefore essential to explore ways of speeding up this phase of the wagon's journey. Apart from the need to accelerate the overall transit time, economies must be sought in the cost of motive power for shunting duties. At present the engine-hours attributable to shunting exceed those worked by locomotives hauling freight trains along the lines. Two approaches are being considered ; first, the possibility of getting better results by changing the location of yards, and, secondly, by the construction of new or redesigned hump yards with centralised operation of points and retarders to control the speed of wagons. The rate of loading and unloading at the larger freight terminals is also very much in mind and substantial developments are taking place in the use of conveyors, fork lift trucks, pallets and other mechanical appliances.

The concentration of road collection and delivery services based on a relatively small number of railheads, which has taken place over the last few years, had as one of its objects a reduction of the expensive trip working of wagons to and from numerous places in the neighbourhood of the main trunk haul centres. I would suggest that when the replanning of marshalling yards or freight terminals is being examined it might be well to consider the advantages which would accrue from locating railhead terminals immediately adjacent to the yards in order to reduce still further the amount of trip working involved.

It must not be overlooked, however, that the majority of wagons are not loaded or discharged by railway staff, and if a really substantial reduction is to be made in the stock of wagons in use it is essential that the co-operation of the railways' customers should be enlisted. It has become too much the habit to regard the railway wagon as a very convenient form of temporary storage and whenever the producer is forwarding traffic at a faster rate than the receiver can accept it, the railway wagon is unblushingly held under load until it is convenient to discharge it. I have been told that one factory which receives raw materials partly by road and partly by rail deliberately allows the loaded railway wagons to accumulate during the week so as to be assured of a continuity of supply over the week-end when the road hauliers are not working ! It is, in fact, the general experience that traders invariably give priority to the unloading of road vehicles. Perhaps this is due to the fact that each vehicle is in the charge of a man who would not, I imagine, silently acquiesce in becoming a temporary storekeeper. Be that as it may, I am certain that if road vehicles were detained for even a quarter of the time that railway wagons are held, our competitors would have to review their charges. It is true that the railways have their demurrage regulations, but the scale of charges for the detention of wagons, after an extremely generous free period, is not adequate compensation for the additional cost involved. It may be that far more stringent demurrage charges will need to be applied in order to speed up the turn-round of railway wagons and enable the total stock to be reduced. Competition is the order of the day in transport and if traders insist that rail rates must not exceed those offered by road hauliers, it is only fair that they should treat the railway wagon with as much respect as they treat the road vehicle, or recognise that it is not unreasonable to be expected to bear the cost of the additional service provided.

Staff.—It may appear that in making this review I have paid much more attention to the utilisation of rolling stock than of manpower. The reason for this is that it is generally the case that better utilisation of equipment automatically opens the door to the more productive use of staff. You will recall that in the examples of replanning passenger services in South Wales and East Anglia, which I mentioned, there were substantial savings in train staff. An acceleration of freight services arising from an increase in the number of power braked wagons would widen the scope for rostering trainmen to work out and home within a turn of duty and thereby either avoid overtime or reduce the number who have to return to their depots as passengers. Mechanisation of marshalling yards and freight terminals would also yield economies in manpower. In fact, there are relatively few directions in which the more intensive use of equipment could not be coupled with a reduction in the unremunerative time of the staff.

Books of Reference

F.B.I. Register of British Manufacturers, 1955. London : Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price £2 2s.—This "Register" includes the names of more than 6800 member-firms of the Federation of British Industries, classifying them under approximately 5000 trade headings. French, German and Spanish glossaries have been added to this edition of the "Register," giving translations of all the headings used in the classified section. The headings are numbered for easy reference between the translations and the other sections. Information is also given about trade associations, proprietary names and trade marks. The "Register," which is now in its twenty-seventh edition, is the official directory of the Federation of British Industries.

Statistical Year Book of the World Power Conference. No. 7. Edited by F. Broun. London : Lund Humphries and Co., Ltd., 12, Bedford Square, W.C.1. Price £2.—This year book contains statistics of world fuel and power resources for the years 1950 to 1952, and for the year 1953 as well where figures were available. Statistics of resources, production, stocks, imports, exports, and consumption of power and power sources are given for all the countries from which information could be obtained. The power sources included are coals, brown coal and lignite, peat, coke, manufactured fuel, wood, petroleum, benzoles, alcohols, natural gas, manufactured gas, water power and electricity. There are explanatory notes about the tables and their sources, and a bibliography of publications on fuel and power statistics is given.

Research in Aeronautics at the National Bureau of Standards

BY OUR AMERICAN EDITOR

As progress in the field of aeronautics to-day has become increasingly dependent upon research and development work in engineering and physics, the National Bureau of Standards, Washington, D.C., is conducting a considerable part of this work on behalf of various American Government agencies. As part of a comprehensive effort aimed at the development of faster, safer and more reliable aircraft, the Bureau is engaged in individual projects in the fields of physics, mathematics, chemistry, metallurgy and various branches of engineering. Much of this work is being undertaken in co-operation with the U.S. Department of Defence, the Civil Aeronautics Administration and the National Advisory Committee for Aeronautics.

THE National Bureau of Standards, Washington, D.C., is engaged in a considerable amount of research and development work relating to aeronautics. Much of this work is being done in co-operation with and on behalf of American Government agencies, as exemplified by current studies of turbulence in supersonic wind tunnels for the National Advisory Committee for Aeronautics and of aircraft lighting for the U.S. Navy Bureau of Aeronautics. As the custodian of the national standards of physical measurement, the Bureau carries on research leading to improved methods of measurement and calibration which are often of value in aeronautical instrumentation. Thus, work on pressure standards and humidity measurement has been applied to aeronautic barometers, altimeters and hygrometers. From time to time, the Bureau's facilities for basic investigation into the properties of matter have been utilised to solve problems in aeronautical research. For example, when condensation of the constituents of air became a serious problem in the operation of hypersonic wind tunnels, the N.B.S. undertook research on heats of vaporisation, phase behaviour and other properties of oxygen, nitrogen and their mixtures. In addition, much of the information which has been obtained in the programme on properties of materials—especially plastics, metals, fuel components and ceramics—is pertinent to aircraft design and has provided a basis for other studies relating to the specific problems of the American aircraft industry.

Aircraft Structures

In the study of aircraft structures, the Bureau has carried on a continuing programme for more than thirty years. During this period emphasis has shifted from the early work on rigid airships to the present structural problems of high-speed aircraft. Currently this programme, which is supported by the U.S. Navy, the U.S. Air Force, and the N.A.C.A., is concerned particularly with swept-back and delta-wing configurations and with the effects of aerodynamic heating and vibration. The efforts of the Bureau in this field have continually been directed toward increased safety and improved performance. For example, a limit load gauge was recently developed to provide a simple means for determining whether basic structural components of operational aircraft have been stressed beyond safe limits. Extensive service tests of the gauge on high-speed fighter aircraft have proved its value as a safety device and have provided data which suggest that it may find use on other designs of aircraft. Numerous studies of aircraft sub-assemblies and structures have been made to provide design information for applications where gust and manœuvring loads are unavoidable. In the course of the work, the Bureau has developed theories for computing the stiffness of wings in flutter calculations and has conducted simulated landing-impact tests to check current theories on the dynamic loads encountered in aircraft during landing. Methods have also been devised for determining the properties of the thin sheet material used in aircraft under both compressive and shear loads. Studies have been carried out for the U.S. Navy at elevated temperatures on panels which are representative of high-speed wing surfaces. These studies provided the data needed in the design of supersonic aircraft where aerodynamic heating is likely to reduce strength seriously. In another project, the Bureau has developed methods of analysis for swept-back and delta-wing configurations and has adapted these methods for use with modern high-speed electronic computers. To provide the data needed in the design of aircraft to avoid fatigue failure, a continuing programme of fatigue testing of representative aircraft structural components is in progress. In connection with this programme, the Bureau is developing instruments to measure fatigue damage to aircraft structures. One of these instruments is a statistical accelerometer for counting the number of bumps to which an aircraft has been subjected, while the other is a fine wire designed to fail before the structure and thus to act as a warning indicator. The creep behaviour of aircraft joints at moderate temperatures is now being investigated to provide design information for high-speed aircraft in which the skin is heated by air friction. The comparative performance of typical structural adhesives and rivets in aircraft structures has been studied as well as the performance of sandwich panels assembled with the aid of adhesives.

Strain gauge determination of stress distribution in a swept-back wing specimen under load

Aerodynamics

In the field of aerodynamics, the National Bureau of Standards has conducted investigations of laminar and turbulent flow in boundary layers over surfaces, developed equipment for measuring turbulence at speeds up to twice the speed of sound, and studied the nature and effects of turbulence in supersonic wind tunnels. This work has been sponsored by the N.A.C.A. and the U.S. Office of Naval Research. Since the mixing action of turbulence in a boundary layer is the controlling factor in the maximum lift of an aircraft wing, and as it is also the factor contributing most to the air friction on the skin of the aircraft, emphasis has been placed on the origin of turbulence and on the mechanics of turbulent motions in the Bureau's work on boundary layers. Hot-wire anemometers, which respond to small-scale, rapidly changing motions, are being used to measure the turbulent motions. The results have provided some indication of how and under what conditions turbulence begins, what turbulent motions are, and what the motions do to the flow about a body. In a recent investigation, an attempt was made to learn as much as possible about the nature of turbulent motions by known experimental techniques. Laboratory measurements were used in various ways to derive such information as where and in what quantities turbulent motions were produced and where and at what rate turbulent motions were dissipated by viscosity. The advent of high-speed flight has made it necessary to measure turbulence in supersonic wind tunnels. A long-range investigation is now being conducted to determine the possibilities of the hot-wire anemometer as a research tool in this field. The factors affecting the cooling of fine heated wires are being investigated in the transonic and supersonic speed ranges. The potentialities and limitations of the instrument are gradually being obtained as studies are being made of the sensitivity of wires as small as 0·00005in in diameter to air speeds twice the speed of sound.

Instrumentation and Equipment

Research and development on aeronautical instruments and apparatus are being performed largely for the U.S. Navy Bureau of Aeronautics and the U.S. Air Force. The work includes projects on pressure and humidity measurement; aircraft oxygen apparatus; aerological instrumentation for measuring pressure, temperature and humidity, and the development of selected flight test instruments. Special equipment has been designed for testing hygrometers at temperatures ranging from −40 deg. Cent. to +50 deg. Cent., and an electrical hygrometer with improved performance is under development. In recent years stick-and-pedal-force indicators, angle-of-attack indicators, pitot and suspended static tubes, and pitch-and-heel-angle indicators have been developed for the Bureau of Aeronautics for use in flight testing. A research programme on corrugated diaphragms has also been undertaken for the U.S. Air Force.

Two designs of compasses have been developed by the N.B.S. in co-operation with the Navy Department. In one of these, eddy-current damping is substituted for the often troublesome method of liquid damping. This compass has been designed to serve as a stand-by unit in the event that the electronic compass fails and for use on abandoning aircraft over ocean or waste areas. The other design is the sky compass, which is based on the work of the late Dr. A. H. Pfund of Johns Hopkins University. The sky compass utilises the direction of polarisation of the light of the sky with reference to the sun. If the clear sky is illuminated by sunlight, even after sunset, the sun's azimuth can be determined by the instrument, and the direction of flight can thus be established. This compass is clearly of importance in polar navigation where the magnetic compass cannot be used.

The recent trends toward high-altitude flight and the more efficient utilisation of weight and space in aircraft have led to a much wider application of pneumatic systems for performing such high-speed operations as extending and retracting the landing gear, emergency canopy or seat ejection, gun charging and rocket ejection. To further the development and technical evaluation of pneumatic systems and equipment, the Bureau, with the co-operation of the Bureau of Aeronautics, has established a pneumatics laboratory equipped with high-pressure, high-capacity facilities. The new laboratory has developed instrumentation to study the pneumatics of high-pressure, short-duration transient flow and is now engaged in the technical evaluation of air-borne pneumatic systems and indivi-

dual components such as actuators, pressure reducers, special-purpose valves, storage reservoirs, and other related equipment. Parallel theoretical and experimental investigations are also being conducted in the fields of the thermodynamics and mechanics of fluid flow.

Navigation and Communications

Much of the Bureau's work in the field of radio has been of direct assistance to air navigation and communications. In the late twenties and the early thirties, the N.B.S. was engaged in the development of wireless aids to air navigation for the U.S. Department of Commerce. This period saw the completion of some of the basic systems upon which the present air navigation systems are based. Since about 1928 wireless beacons have been used to mark the airways of the United States. This method, which involves the interlacing signals on two loops of a figure-eight pattern, was originally proposed by the Bureau in 1924. About 1929, scientists of the N.B.S. proposed and developed a wireless guiding beam for instrument landing purposes, and by the end of 1933 they had demonstrated a complete system for the blind landing of aircraft. The system not only increased by a large factor the safety of landings, but also made it possible for aircraft to operate under conditions of visibility that would otherwise have made flight impossible. Once adopted and adapted by the U.S. Civil Aeronautics Administration, this instrument-landing system became the basis of the present universally used "I.L.S." blind landing system.

To-day the National Bureau of Standards Central Radio Propagation Laboratory, which was described in THE ENGINEER of September 17, 1954, serves as the primary agency of the U.S. Government for research in radio wave propagation and for the centralisation and co-ordination of information in this field. It receives and analyses data from a widely separated network of ionospheric sounding stations and predicts in advance the best frequencies for use in world-wide wireless communications. A large part of this programme has a direct bearing on aircraft navigation and communications. For example, an important project now under way is concerned with basic propagation research for a unified system of air communications, navigation and traffic control to operate in the frequency range of 960Mc/s to 1600Mc/s. A comprehensive investigation of the problems involved has been undertaken at the request of the Air Navigation Development Board of the Civil Aeronautics Administration. To determine the necessary propagation factors for the effective allocation and use of these frequencies, the Bureau has established research facilities at Cheyenne Mountain, Colorado. The N.B.S. also establishes, develops and maintains standards and methods of measuring electrical quantities throughout the ranges of wireless and micro-wave frequencies. Included in this work are standard time and frequency signals which are broadcast continuously by the Bureau's radio station "WWV" at Beltsville, Maryland, and by an experimental station, "WWVH," in Hawaii.

Aviation Lighting and Visibility

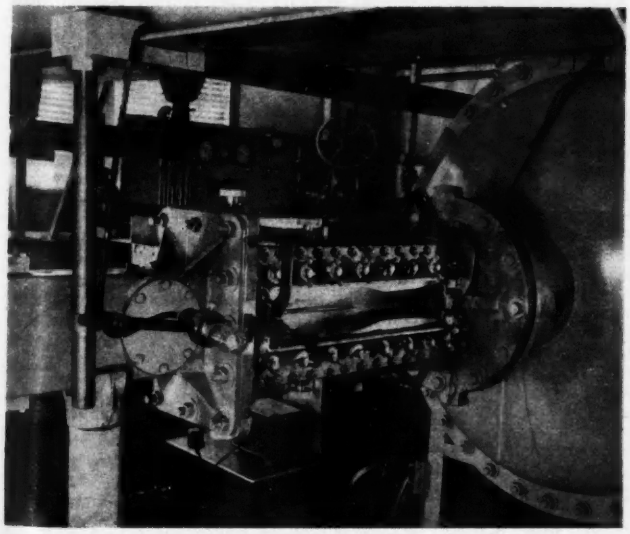
Aviation lighting has long been an active field at the N.B.S. The Bureau has assisted the Civil Aeronautics Administration in the development and evaluation of approach-light systems from the time these lights were first considered. Similar work has been the development of airway beacons and course lights and of position lights which are used to identify the course and position of aircraft to other aircraft. The N.B.S. also co-operates in the international co-ordination of specifications for the colours of aviation signal lights, and performs work for the U.S. Weather Bureau on the determination of visibility at airports. It has been found that the accurate measurement of ceiling and visibility is often an important element in safe landings. During periods of restricted visibility, electronic aids are used to complete the landing. However, measurements taken at a weather station sometimes as much as 2 miles away, do not always give a true picture of the runway conditions. For accurate measurements of the ceiling along the active runways, the N.B.S. developed the "ceilometer" for the U.S. Weather Bureau several years ago. The "transmissometer," an instrument for the measurement of visibility in landing areas, was developed subsequently. During tests, remote-recording equipment installed on these instruments provides a continuous record of the ceiling and visibility conditions of fogs at the critical sites. The instruments also give personnel in the control tower a much better idea of the conditions existing throughout the approach zone and along the runway than would be obtained by visual observations.

The N.B.S. is now doing work for the Bureau of Aeronautics on aircraft lighting, aviation ground lighting, visual range meters, and visual landing aids. The aircraft lighting projects include the development and evaluation of anti-submarine searchlights, instrument and control panel lighting devices, and cockpit lighting control systems. In connection with the aviation ground lighting work, the "Kinorama"—a device that enables a pilot to evaluate a system of approach lights without leaving the ground—was developed; its use in the training of pilots is now being studied. Important contributions to naval aircraft lighting include the development of the individual instrument lighting fixture, improvements in interior red lighting for maintenance of dark adaptation, continued improvement in searchlight operation, and standardisation of the colours of identification lights.

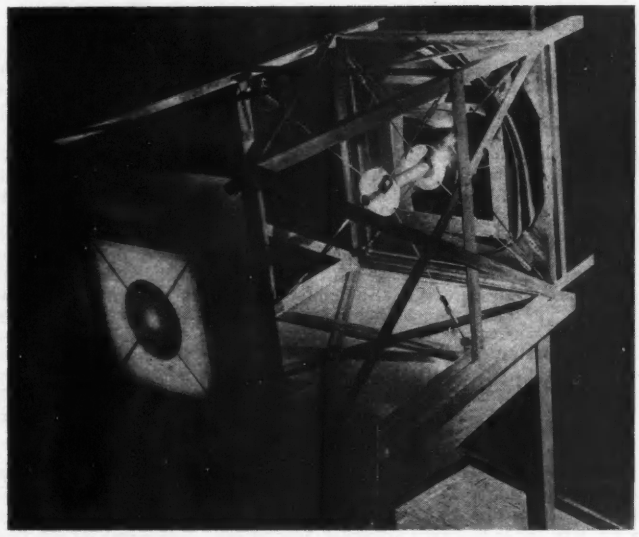
Other projects in the general field of optics are concerned with the design of lenses for use in reconnaissance and mapping. Under the sponsorship of the U.S. Air Force, automatic computing machines are being used for experimental designs of extremely wide-angle lenses and also for lenses of high numerical aperture for night photography. At present, the Bureau is providing technical supervision of an Air Force contract with private industry for the investigation and development of production techniques to be applied in the manufacture of large optical elements of high quality. This glass will be used for camera lenses for high-altitude reconnaissance, for wind-tunnel optics, and for other critical applications.

Aircraft Engines and Fuels

Although gas turbines and jet engines are being increasingly utilised, particularly by the military services, much research and development remain to be done on components in order to attain the desired reliability, economy, performance and safety. In this field the National Bureau of Standards is concerned with problems of burning gaseous mixtures, of fuel handling and metering, and of determining the composition and temperature of the products of combustion in gas turbines and other air-breathing jet engines. A continuing programme of combustion research, which has been sponsored by the U.S. Navy Bureau of Aeronautics since the beginning of the last war, includes both basic and applied studies of burning velocities, flame temperatures, gas sampling and mixing and the development of design and performance data on combustors for turbo-jets, ram-jets and after-burners. Another phase of the work for the Bureau of Aeronautics is concerned with the development, evaluation and improvement of test equipment for the components of aircraft fuel systems. The original emphasis on carburetters has since shifted to the corresponding parts of turbo-jet engines, and a hydraulically-driven test bench for jet fuel-control units is now under development. Still other projects, sponsored by the U.S. Air Force, deal with conventional and spectroscopic methods for measuring the temperature of hot gases flowing at high velocities, and with low-voltage, high-energy ignition systems for turbo-jet engines. Much of the current work on thermal properties of gases has been undertaken to provide accurate thermal data on the gases which flow through jet engines or wind tunnels, or which an aircraft must encounter in the atmosphere. With the co-operation of the N.A.C.A., the Bureau recently completed the calculation and compilation of 100 tables giving the thermodynamic and transport properties of such gases as oxygen, nitro-



Hot-wire anemometer in use at the test section of the supersonic wind tunnel at the N.B.S.



Apparatus for focusing aircraft searchlight reflectors and determining their quality by examination of the shadow pattern on the screen

gen, hydrogen, carbon dioxide, carbon monoxide, argon and steam from low temperatures and pressures to 3000 deg. K. and 100 atmospheres. Work in this general field is continuing and includes studies on the thermodynamic properties of air and the heats of combustion of jet fuels. Other projects are concerned with the determination of the temperature of very hot gases and a study of the thermal conductivities of jet engine exhaust gases.

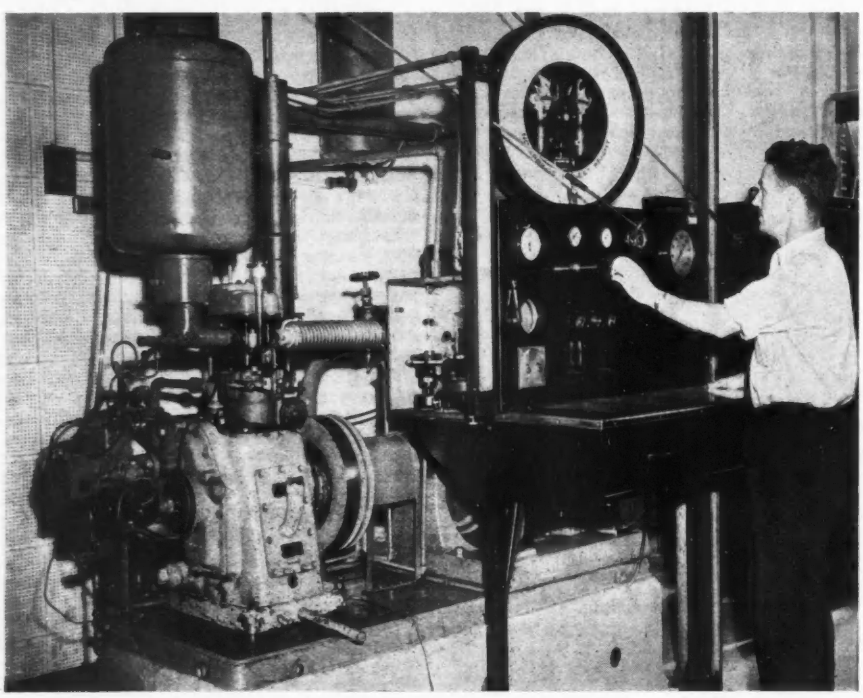
Basic work on the problem of knock in reciprocating engines has been conducted for several years. The relationship between the structure of hydrocarbon fuel molecules and their tendency to knock was developed from measurements on many very pure hydrocarbons synthesised at the Bureau. This work provided some of the basic information needed for the development of high-octane fuels. Investigations of the relation between the structure of the fuel and its burning velocity, combustion efficiency, heat of combustion and other properties of interest in connection with jet fuels were also made possible by the use of synthesised hydrocarbons. The actual mechanism of the chemical reactions taking place in combustion and their effect on knock are now being studied in three separate projects. Developments in this field include new and improved instrumentation ; an example is a device that will extract an analytical sample of gas from an engine cylinder in 0·0002 second.

The N.B.S. maintains the primary standards for the determination of the octane numbers of both automotive and aviation fuels. With the co-operation of the American Society for Testing Materials, research is being carried on to increase the accuracy of these standards and to develop improved measuring instruments and apparatus. The Bureau is also responsible for determining and maintaining standards of viscosity. In connection with this activity, basic lubrication studies are conducted on the characteristics of fluids, greases and bearings for use in mechanical equipment.

High-Temperature Materials

The combustion products in the newer and more powerful aircraft engines, particularly jet engines, are hotter and more destructive than those in the engines of a few years ago. At the same time the enormously increased demand for highly heat-resistant alloy parts has brought about an urgent need for minimising the strategic metal content of alloys. In this respect the application of protective ceramic coatings has made possible the use of heat-resisting alloys of much lower strategic metal content than would otherwise be possible. For example, a coated 18 per cent chromium, 8 per cent nickel stainless steel is now being used for jet engine combustion chamber liners instead of a 78 per cent nickel, 14 per cent chromium alloy. Without the coating, the lower alloy part would burn through in a comparatively short operating period.

During the last war, the National Bureau of Standards developed the first American high temperature ceramic coating for steel to be produced commercially on aircraft parts. This coating was used to protect mild steel exhaust stacks, which, if uncoated, would have required a heat-resisting alloy with a substantial content of strategic metal. Since the war, the Bureau, working under N.A.C.A. sponsorship, has developed coatings for heat-resisting alloys that are required to withstand considerably higher operating temperatures than could be met by mild steel, even when coated. These coatings were first used extensively on heat exchangers for large bombers, and subsequently on an expanding list of items including jet engine combustion chamber liners and nozzle boxes for turbo-superchargers. More than a score of companies are now producing the coatings and finding new uses for them, and the estimated savings to the U.S. Government run to several million dollars annually. With the support of the N.A.C.A. the Air Force, and the Army Ordnance, the Bureau is also conducting studies of the adherence of ceramics to metals, the effects of ceramic coatings on the creep behaviour of metallic single crystals ; the erosion behaviour of aircraft components as affected by ceramic coatings ; and electrical resistivity of ceramic coatings at elevated temperatures, with special reference to the insulation of electronic components. Under Air Force sponsorship, the Bureau is now studying the use of cermets for turbine blades and as flameholders for afterburners in jet aircraft.



Single-cylinder supercharged test engine at the N.B.S. for determining the pre-ignition rating of spark plugs for aircraft engines. The rating is expressed as the maximum i.m.e.p. at which the engine may be operated before the spark plug tested causes pre-ignition

Aircraft Plastics

Work on transparent and laminated plastics, " dopes " and coatings for aircraft use has been conducted by the Bureau for the Navy Bureau of Aeronautics since 1933. This programme contributed to the initial adoption of acrylic plastics glazing for aircraft and the increased use of laminated plastics for accessories and semi-structural parts. Current work for the Bureau of Aeronautics is concerned with the development and application of new methods for evaluating plastics and promising coating materials, and a survey of the properties of transparent plastics. With the increasing use of laminated plastics in aircraft, a need has developed for more comprehensive information on the properties of these materials in order to evaluate them for aircraft application and to prepare suitable specifications. To provide the necessary data, the N.B.S. has conducted an extensive programme on the properties of plastic laminates. Studies have been made of the effect of simulated service conditions, fuel immersion and extreme temperatures on these materials. Under the sponsorship of the N.A.C.A. and the U.S. Air Force, the Bureau has undertaken a number of different investigations of glass-fibre reinforced plastics, which the Armed Forces have found adaptable to " radomes " and other parts of aircraft. It has been shown that a close control of the many variables involved in production makes possible the fabrication of reinforced plastics with more uniform quality, greater strength and improved electrical properties. The crazing of the acrylic plastic glazing used in aircraft canopies has been a major problem to the industry for some time. Under N.A.C.A. sponsorship the Bureau is now engaged in a fundamental investigation of the nature of the crazing process and the conditions under which it occurs. Recently this work has shown that by hot-stretching the acrylic plastic sheets the material can be made essentially craze-resistant, taking on a laminar structure which gives it improved resistance to bursting when subjected to bullet impact while pressurised.

In aeronautical applications, textiles, plastics and other organic materials are often subjected to shock loading at widely varying conditions of temperature and relative humidity. The stresses and strains thus developed within the material and their propagation through it are important in the evaluation of these materials for aircraft use. The Bureau is now constructing equipment for the classification and evaluation of textile fibres, yarns, cords, fabrics and plastics under very high rates of deformation. A new and simple approach will be used involving determination of the " critical velocity " required to rupture the specimen.

Aircraft Metals

A large part of the Bureau's work in metallurgy has been specifically concerned with aeronautical problems. Studies of the corrosion of aircraft alloys—aluminium, magnesium, stainless steel, titanium and others—have been carried on for the U.S. Navy Bureau of Aeronautics since 1925, providing results of importance in aircraft design. When metallic skin structures were introduced in the early 'twenties, they were at first unsuccessful because inter-granular corrosion caused early failure of the metals used at that time. However, investigation of various heat-treatments for aluminium alloys at the Bureau soon resulted in the development of a " cold water quench " procedure which greatly reduced this kind of corrosion. Later, a chromic acid anodising process was developed to protect aluminium alloys from corrosion. Considerable work has also been done on the stress corrosion resistance of aluminium and magnesium alloys to determine their suitability for use in naval aircraft. As new alloys and coatings or other protective processes are developed, the Bureau continues to evaluate them to determine their suitability for aircraft use. A variety of other metallurgical investigations are being carried on for the Bureau of Aeronautics. Failed parts are regularly submitted to the N.B.S. by the U.S. Navy for examination and diagnosis of the cause of failure. Some years ago a study was made to determine the effect of low temperatures on various aircraft materials. During the last war a number of the " national emergency " steels were evaluated for aircraft applications. Recent investigations have dealt with the intergranular embrittlement of austenitic stainless steels and the solubility of carbon in these steels.

Industrial and Labour Notes

Overseas Trade

The provisional figure given by the Board of Trade as the value of United Kingdom exports in December is £255,700,000, bringing the total for the whole of last year to £2674 million. The Board of Trade says that both in value and volume last year's export figures were the highest ever reached. The value of exports in 1953 was £2582 million.

The effects of the dock strike continued to be shown in the December export figures, although, as had been expected, the shipments recorded in December showed a substantial increase over the November figures. But whereas in the first three quarters of last year recorded exports showed increases of from 4 to 8 per cent over 1953, the monthly average in the fourth quarter was 3½ per cent below the comparable quarter of 1953. The value of December imports has been put at £314,500,000, the total for the whole of last year being £3382·5 million, which was an increase of 1 per cent on the 1953 figure. In the final quarter of last year the monthly rate of imports was £290,400,000, which was 5½ per cent more than in the corresponding quarter of 1953. During last year the value of re-exports showed a downward trend. The re-export figure for December was £8,400,000, the monthly average for the fourth quarter of the year being £7,700,000. The total for the whole of the year was £100,500,000, which was 5 per cent below the 1953 figure.

Taxation and Production Costs

The Association of British Chambers of Commerce has published a statement setting out the suggestions it has submitted to the Chancellor of the Exchequer for consideration in preparing the Budget. In the statement the Association urges that there should be a continued drive to reduce Government expenditure substantially. The State, the Association says, is appropriating some £5000 million out of the national income for Government expenditure, and although an appreciable part of the expenditure provides services which indirectly assist the costs of production, there is a relatively heavier net overhead cost in respect of the Government to be carried by United Kingdom businesses in foreign markets than by their foreign competitors. The United Kingdom, the statement continues, is at the moment sharing in the world increase in exports of manufactured goods, but its rate of increase is less than that of some of its competitor countries, and relatively to them the United Kingdom has failed to maintain its position. The reduction of Government costs, the Association believes, can lead to reductions in quoted prices for British products in export markets.

The statement goes on to say that, as the United Kingdom economy is fully employed, any further expansion in trade, and of well-being, must come from increased efficiency. It is this need for expansion, the Association claims, that should guide the adjustment of taxation. Increased mechanisation and better methods can make a limited supply of labour go further and yet permit increased wages without increasing the costs of production. The Organisation for European Economic Co-operation, the statement observes, has drawn attention to the fact that the United Kingdom is lagging behind its competitors in the proportion of national income being invested in manufacturing equipment.

Dividends and Wages

In his annual statement as chairman of Barclays Bank, Ltd., Mr. A. W. Tuke makes some comments on the subject of profits, dividends and wages. He says that the essential principle in regard to any comparison of wages with dividends is that the expenses of running the business, which include the payment of a fair wage to the employees and the salaried staffs, have to be met in full out of the gross receipts before there is anything at all available for the proprietors. After that, in theory at least, Mr. Tuke adds, everything that the tax-gatherer spares should go to the proprietors, either as dividend or as addition to the reserves, which are their property.

Mr. Tuke goes on to say in his statement that what is a fair wage at any given time may be arguable, but this at least explains why wages moved so far ahead of dividends in the post-war era of inflated prices. That is not to say, the statement continues, that the whole of any further surplus should in fact be paid over to the shareholders. It is likely that, for more reasons than one, the directors of a prosperous business will wish to make service in their company more attractive than service in a rival concern. Whatever form this may take, whether it be in a fund to supplement the State pension, or some bright new paint in the works, it will cost money, but it may be expected to give rise to greater contentment and thus to produce even greater prosperity. Therefore, Mr. Tuke comments, the more prosperous a company is, the better are the prospects for its employees, which, he believes, is a proposition fully accepted by the trade union movement in America.

Mr. Tuke thinks it is a great pity that in this country it seems to be quite widely held in certain quarters that profits are a regrettable, if not a positively wicked, by-product of business activity, and that to be successful is in some way anti-social. He contends that profits need no moral justification and says that if his words should reach the eyes of any doubting Thomas or envious Casca, he hopes "they may serve to allay his doubts or abate his envy!"

Collective Bargaining

The annual statement prepared by Mr. A. Harold Bibby, chairman of Martins Bank, Ltd., contains some observations on trades unions and employers' associations. Mr. Bibby says that to-day every employer welcomes a strong trade union just as all trades unions must welcome associations of employers with whom they can discuss their problems and usually come to a satisfactory settlement.

For this sensible way of settling difficulties, Mr. Bibby continues, it is essential that both parties are determined and capable of seeing that the arrangement arrived at is carried out; otherwise the whole negotiations become a farce, and fall into disrepute and ultimate disuse. The unofficial strike, the statement adds, is the worst enemy of the employee and employer alike. The unions have their constitutionally elected representatives who are authorised to negotiate on behalf of their membership. The very foundation of collective bargaining crumbles when agreements freely negotiated by them are repudiated and a "splinter union within the union" tries to usurp their authority. This is damaging to the unions, Mr. Bibby remarks, and leaves the employers with a very real doubt as to whether the agreements are worth negotiating if they will not be honoured by both parties.

Mr. Bibby goes on to urge that the interests of the employee and employer are one. Both depend on making their industry efficient to enable good pay to be earned, to make profits which enable good dividends to attract fresh capital to the enterprise and to put aside sufficient reserves to ensure the replacement of worn-out machinery. It would be more understandable, Mr. Bibby says, if employees tabled complaints, should these three conditions not be fulfilled, on the grounds that the management, their fellow workers, or both, were not giving of their best. The more common practice of making excessive demands or resisting the introduction of modern machinery and methods can only result in pricing the products of their labour out of the international market.

Trade Mission to Egypt

The Board of Trade has announced that the trade mission which is to tour Egypt, the Sudan, and Ethiopia will leave London on January 29th. This mission will be led by Sir Edward Benthall and Mr. G. C. R. Eley, the other members being Mr. A. W. Berry, M.I.Mech.E., director of the British Engineers' Association; Mr. A. E. J. Gawler, deputy overseas controller of Imperial Chemical Industries, Ltd.; Mr. Maurice Laing, managing director of John Laing and Son, Ltd.; Mr. T. A. L. Paton, M.I.C.E., of Sir Alexander Gibb and Partners; Mr. J. F. Perry, managing director of Metropolitan-Vickers Electrical Export Company, Ltd.; Mr. G. Phillips, of Scales and Adam, Ltd.; Colonel R. E. M. Pratt, of the British Motor Corporation; Mr. P. G. G. Salkeld, of Steel Bros. and Co., Ltd., and Mr. J. C. Tremayne, of Tootall Broadhurst Lee Company, Ltd. It is stated that arrangements have been made for the mission to meet Ministers, senior officials, prominent business men and representatives of Chambers of Commerce, and to visit a number of factories, public works and other centres of commercial and industrial interest.

Industrial Welfare Society

The twenty-seventh annual general meeting of the Industrial Welfare Society was held in London last Tuesday. In an introduction to the Council's report, the director, Mr. John Marsh, says that the Society's attitude towards the difficulties facing industry to-day is to ensure that, in the drive for greater productivity, human problems are not overlooked, nor the fact that harmonious relations are one of the keys to progress. The report mentions some "unresolved developments" affecting human relations in industry, and includes among them work study, company training, the shortage of training officers and employee services. In a reference to the problems of small firms, the report says that in this country there are 51,008 establishments each employing fewer than 250 people. Nearly 40 per cent of the industrial population of Britain is, in fact, employed in these small firms, a matter, it is suggested, which is too often neglected when studies of British industry are made. The report goes on to say that small firms can retain the loyalty of their employees in spite of indifferent working conditions because such firms often employ a high ratio of skilled men who find an intrinsic satisfaction in their trades, and because the close contact with the owner or manager is much valued by the employees. They know from day to day, the report comments, how the firm is doing, and there is consequently a true feeling of "belonging."

Speaking at last Tuesday's meeting, the chairman, Mr. H. H. Bagnall, said that the Society had continued to adapt itself to the changing pattern of industry as it evolved. In its early days, he recalled, the Society was largely concerned in advocating ways in which employers could provide welfare facilities at work, and also assisted in promoting sports, social and cultural activities. During and since the second world war, however, much more attention had been given to the human factor in the cultivation of good relations in industry. When the development of joint consultation and the other methods of communication were considered, as well as the tremendous increase in education and training schemes, it would be seen that the role of the Society had widened very considerably since its early days.

Iron and Steel Import Duties

The Board of Trade says that after consultation with the Iron and Steel Board about the supply position, the Government has decided to make a new Order affecting the temporary suspension of import duties on iron and steel. The Order prolongs the temporary suspension of import duty on cold rolled steel sheets of a value of less than £80 per ton until March 18, 1956; and suspends until September 18, 1955, the import duties on many iron and steel products. The duties on some of these had already been suspended until March 18th next. The new Order, which is known as the Import Duties (Exemptions) (No. 1) Order, 1955 came into operation on January 14th. It replaces the Import Duties (Exemptions) (No. 6) Order, 1954.

Personal and Business

Appointments

MR. A. E. BELL has been appointed sales manager (engineering) of Distington Engineering Company, Ltd., Workington, Cumberland.

SIR RICHARD E. YEABSLEY, C.B.E., has been appointed a director of Ruberoid Company, Ltd., Commonwealth House, 1–19, New Oxford Street, London, W.C.1.

DR. A. W. SKEMPTON, Reader in Soil Mechanics at the Imperial College of Science and Technology, London, has been appointed to the University Chair of Soil Mechanics at that college.

THE BRITISH TRANSPORT COMMISSION has announced the appointment of a Docks Management Board. Sir Robert Letch is the chairman, the other members being Mr. John Donovan, Mr. R. P. Biddle and Mr. A. E. H. Brown.

MR. J. H. B. CHAPMAN, M.I.N.A., has been appointed principal deputy director in the department of the Director of Naval Construction, Admiralty, in succession to Mr. H. S. Pengelly, C.B., M.I.N.A., who has retired.

MAJOR-GENERAL LLEWELYN WANSBROUGH-JONES, C.B., is shortly to join the British Transport Commission and will take up the office of secretary-general in succession to General Sir Daril Watson, who will be retiring in May next.

MR. L. J. M. KNOTTS has been appointed signal engineer in the Scottish Region of British Railways, in succession to Mr. W. Bryson, who has retired. Mr. J. F. K. Davidson has been appointed motive power superintendent in the Ayr district.

DR. GEORGE W. RIGBY has been appointed European technical representative of E. I. du Pont de Nemours and Co. Dr. Rigby, who has been associated with the company since 1930, will have his headquarters at the main offices at Wilmington, Delaware, U.S.A., but will spend a good deal of his time travelling in Europe.

ARMSTRONG SIDDELEY MOTORS, Ltd., Parkside, Coventry, states that the duties of Mr. W. A. Henley, commercial manager and assistant to the general manager, have been extended to include overall responsibility for administration. Mr. E. Hessey now has overall responsibility for car sales, service and spares at home and overseas, and Mr. John Jennings has been appointed home sales manager of the car division.

THE BRITISH ELECTRICITY AUTHORITY states that it will retain the services of Mr. J. F. Field, M.I.C.E., M.I.E.E., controller of its South East Scotland division, when the division is taken over by the South of Scotland Electricity Board on April 1st. Mr. Field will be employed initially in the headquarters engineering department, under the chief engineer, on special duties connected with the development of plant and equipment to operate on the Field cycle.

SIR SUMMERS HUNTER is retiring at the end of the month from the office of managing director of the operating companies in the Richardsons Westgarth group, but he will continue to serve on the boards of those companies. Mr. Harry Hunter has therefore been appointed managing director of The North Eastern Marine Engineering Company, Ltd., Mr. T. P. Everett, managing director of Richardsons Westgarth (Hartlepool), Ltd., and Mr. W. R. Jones, managing director of George Clark (Sunderland), Ltd.

SHEEPBRIDGE ENGINEERING, Ltd., Chesterfield, states that Mr. G. E. H. Hall has been appointed a director of Sheepbridge Stokes, Ltd., and of British Van der Horst, Ltd. Mr. Hall is the general manager of Sheepbridge Stokes, Ltd. Mr. R. Gore has been appointed general manager of the engineering division, and Mr. C. Hand general manager of the foundry division, of Sheepbridge Equipment, Ltd. Mr. J. R. Jenkins has been appointed methods engineer for the southern group of Sheepbridge companies, comprising Automotive Engineering, Ltd., Hardinge Machine Tools, Ltd., Light Production, Ltd., Clews Petersen, Ltd., and Sheepbridge Engine Repairs, Ltd. Mr. E. A. Macdonell has become southern area sales representative of Automotive Engineering, Ltd., Twickenham, and Mr. F. W. Simmons has been appointed manager of the London branch of Sheepbridge Engine Repairs, Ltd.

Business Announcements

CROSBY VALVE AND ENGINEERING COMPANY, Ltd., states that an extension to its works at Ealing Road, Wembley, is now nearing completion.

MARTIN, BLACK AND CO. (WIRE ROPES), Ltd., Coatbridge, has opened a stores depot at 640, Woodborough Road, Mapperley, Nottingham (telephone, Nottingham 47293).

DR. A. G. WHITE has retired from his position as managing director of the Nobel division of Imperial Chemical Industries, Ltd., after forty years' service with the company and its predecessors.

SHEEPBRIDGE EQUIPMENT, Ltd., states that Machinery (Continental), Ltd., 175, Brompton Road, London, S.W.3, is the sole distributor of the Jules Weitz tower cranes built at the Sheepbridge Works, Chesterfield.

THOS. W. WARD, Ltd., Albion Works, Sheffield, states that it has taken control of George Hassall, Ltd., Cobridge, Stoke-on-Trent. Mr. S. J. Dyal and Mr. H. Vernon, directors of Thos. W. Ward, Ltd., have joined the board of George Hassall, Ltd., and Mr. R. Deaville continues as resident director.

THE BRITISH TRANSPORT COMMISSION has announced the retirement of Mr. C. H. Nicholson, M.I.Mech.E., M.I.E.E., from his position as mechanical and electrical engineer, Humber Ports. He is remaining in the service of the British Transport Docks Division in an advisory capacity as mechanical and electrical engineer (general duties).

JACK OLDING AND CO., Ltd., Hatfield, states that its research and development department has been acquired by Mr. William Wharton. Mr. Wharton has resigned from the board of Jack Olding and Co., Ltd., and will carry on the research and development business at Watford Road, Elstree, Herts, under the style of Wharton Engineers (Elstree), Ltd.

MR. JOSEPH WALTON is retiring at the end of the month from the position of joint managing director of Thos. W. Ward, Ltd., Albion Works, Sheffield. Mr. Walton, who joined the firm fifty years ago, was appointed joint managing director in 1950. He will retain his appointments as chairman and managing director of The Darlington Railway Plant and Foundry Company, Ltd., Darlington.

THE RHEOSTATIC COMPANY, Ltd., Slough, Bucks, states that negotiations are almost complete for the portion of its business concerned with the manufacture and supply of unbreakable resistors to be taken over on April 1st by Metal Industries, Ltd., Glasgow. The Rheostatic Company, Ltd., will concentrate wholly on the production and development of its temperature control equipment.

Contracts

THE DE HAVILLAND AIRCRAFT COMPANY, Ltd., has received an order from the Ministry of Supply for "DH.110" all-weather interceptors for service in the Royal Navy.

THE CLAYTON EQUIPMENT COMPANY, Ltd., Hatton, Derby, states that it has received from Poland an order for fourteen battery-operated mining locomotives, valued at over £100,000.

STEWARTS AND LLOYDS, Ltd., has received an order for the supply of 490 miles of pipeline from the prime contractors, Brown-Raymond-Walsh, for the American bases in Spain. The value of this contract is approximately £2,000,000.

MODERN WHEEL DRIVE, Ltd., has received an order to supply two Hindmarch-MWD twin-engine, oil-operated reverse reduction gears for coupling to four Fairbanks-Morse engines, each of 2000 b.h.p. at 750 r.p.m., to give a propeller speed of 200 r.p.m. The machinery is to be fitted in a Hydrographic Survey ship being built by Canadian Vickers, Ltd., for the Canadian Government.

MCCALLS MACALLOY, Ltd., Templeborough, Sheffield, has received an order for about 500 tons of "Macalloy" steel for the new Kallang Basin Bridge at Singapore, which is to be built on the Lee-McCall system of prestressed concrete. This bridge will consist of twenty-five spans of 80ft, making a total length of 2000ft and a width of 65ft. The Lee-McCall system is also being used by the Hindustan Construction Company, of Bombay, in the new Mahi Bridge, near Baroda, in which there are sixteen spans of 110ft.

THE GENERAL ELECTRIC COMPANY, Ltd., announces that its Fraser and Chalmers Engineering Works, Erith, Kent, has received an order from Colvilles Ltd., for a 500-ton-per-hour capacity ore handling plant, with motors and control gear, for the company's stock yard at Clyde Iron Works, Glasgow. The plant, based on an existing travelling transporter spanning the ore stock yard, includes a 950ft long conveyor running parallel with the stock yard which will deliver the ore to another conveyor. The second conveyor will be 700ft long and will in turn deliver to an ore screening station for which all the screens, local conveyors and associated gear will also be supplied. To allow ore to be diverted to a possible future crushing plant, a reversible belt feeder will be sited at the junction of the two long conveyors.

Miscellanea

OBITUARY.—We hear with regret of the death, on January 13th, of Dr. Ernst Homberger, honorary chairman of Georg Fischer Aktiengesellschaft, Schaffhausen. Dr. Homberger, who was in his eighty-sixth year, had been with the company for over fifty years and had played an important part in its development.

DIESEL-HYDRAULIC SHUNTING LOCOMOTIVES.—Six metre-gauge diesel-hydraulic locomotives for shunting duties have recently been completed at the works of the North British Locomotive Company, Ltd. These locomotives are six-coupled and from a 360 h.p. Paxman engine the power to the wheels is transmitted through hydraulic transmission and a final drive jackshaft which drives through side rods. In full working order each locomotive weighs 36 tons and has a tractive effort at 30 per cent adhesion of 24,200 lb.

SHELL MOULDING.—The Association of Bronze and Brass Founders has issued an interim report of an objective survey which is being made of the shell moulding process. This survey is being made on behalf of the Association's advisory service by Mr. J. L. Rice, of the British Non-Ferrous Metals Research Association. The interim report is the result of three months' consultation with makers of shell moulding equipment, suppliers of resins and users of the process. It contains a summary of the developments so far made and an appraisal of their usefulness. Copies of the report are available from the Association's offices at 69, Harborne Road, Birmingham, 15, price 5s. each.

HANDBOOK OF FITTING AND MACHINING EXERCISES.—The Society of British Aircraft Constructors has produced a handbook of practical exercises which will be of direct assistance to those responsible for apprenticeship training in all branches of the aircraft industry. Examples range from elementary exercises in filing, drilling, sawing, tapping, reaming, &c., associated with an introduction to the use of hand tools to details of simple fitting and machining operations leading to the assembly of typical tools and workshop equipment. Copies of the handbook, price £4 15s. each, can be obtained from the Society of British Aircraft Constructors, Ltd., Technical Section, Summit House, 1/2, Langham Place, London, W.1.

RADAR CATHODE RAY TUBES WITH ELECTROSTATIC FOCUS.—Two sizes of radar cathode-ray-tube, 9in ("AF22-10") and 12in ("AF31-10"), having electrostatic focus instead of electro-magnetic focus, have been introduced by Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2. The elimination of the setting-up procedure associated with electromagnetic focus is an inherent advantage of the new tubes. Hitherto it has been difficult to realise this advantage, because a voltage of about 2000V has been required for electrostatic focus. In the new Mullard tubes, however, a comparatively small focus electrode voltage is used. With a final anode voltage of 12kV, the tube has a focus voltage which can be preset between ±200V with reference to the tube cathode potential, to ensure fine focus. This voltage range can be obtained by inserting a preset potentiometer of low power rating across the h.t. supply, since the focus electrode itself draws a current of only about 15 microamperes.

VISIT TO LONDON OF PROFESSOR NERVI.—Professor Pier Luigi Nervi, the well-known Italian structural concrete designer, is to pay a four-day visit to London in February. On Thursday, February 24th, he will lecture on "Some Reinforced Concrete Structures in Italy," at the invitation of the Institution of Structural Engineers, the Cement and Concrete Association and the Reinforced Concrete Association. Professor Nervi is the designer of such works as the Turin Exhibition Halls with their reticulated arched roofs, and the lattice-roofed hangars of the Florence Stadium. His most recent work is the new palace for U.N.E.S.C.O. in Paris, on which he is collaborating as engineer with the architects Marcel Breuer and Bernard Zehrfuss. Professor Nervi's lecture is being given in the Central Hall, Westminster, at 6 p.m. on Thursday, February 24th. Members of the Institution of Structural Engineers and of the Reinforced Concrete Association are asked to obtain tickets from their respective secretaries; others may obtain them from the Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W.1.

FAIRINGS FOR MINE SHAFT BUNTONS.—Many new collieries are now being constructed or planned by the National Coal Board to work deep, gassy coal, and in these mines large quantities of ventilating air, approaching 1,000,000 cubic feet per minute, will have to be circulated through the workings. Most of the main winding shafts are to be equipped with rigid guides instead of the rope guides commonly used in existing shafts. Rigid guides are usually fixed to horizontal buntons made from "H"-section steel joists spaced at intervals of about 10ft in the shaft, but these buntons add greatly to the resistance of the shaft to airflow, and therefore to the power required to force the ventilating air through it. A deep shaft passing a large volume of air and fitted with rigid guides will absorb a considerable amount of power and it has been found from tests carried out on models in wind tunnels that by fitting stream-line fairings over the buntons, the resistance of the shaft can be halved. A fairing has been designed by Mr. G. Bromilow, ventilating engineer of the N.C.B., and to meet the requirements for strength and corrosion and fire resistance, it is proposed to make it of a plastic such as P.V.C., either unreinforced or having a reinforcement of a material such as glass fibre. The fairing can be sprung on to the bunton joists and is kept in position without the use of clips or bolts.

British Patent Specifications

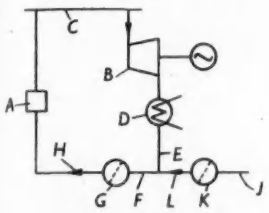
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

STEAM GENERATORS

720,903. April 9, 1953.—TREATMENT OF FEED WATER FOR STEAM GENERATING PLANTS, Sulzer Frères Société Anonyme, Winterthur, Switzerland.

According to the invention, a method of treating feed water for a steam generating plant includes returning condensate to the steam generator through a main salts-removing plant and supplying make-up feed water through an auxiliary salts-removing plant and then through the main salts-removing plant. By this method the risk of insufficiently purified water entering the steam generator is substantially reduced. The invention can also include a main salts-removing plant for the returning condensate and for make-up feed water, preceded by an auxiliary salts-removing plant for the make-up feed water alone. In the plant shown in the drawing the steam raised in the generator *A* passes to a turbine *B* through a steam pipe *C*. The exhaust steam from the turbine is condensed in a condenser *D* and passes as condensate through pipes *E* and *F* to the main salts-removing plant *G*. The condensate



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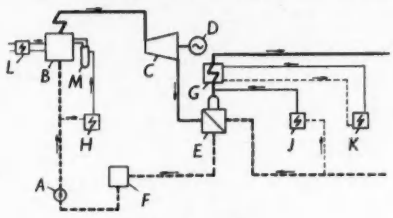
freed from salts is supplied to the steam generator *A* through a pipe *H*. The make-up feed water passes through a pipe *J* into an auxiliary salts-removing plant *K*. The make-up feed water freed from salts passes through a pipe *L* to join the flow of condensate at the junction between the pipes *E* and *F*, so that the make-up feed water must also pass through the main salts-removing plant *G* before it can enter the steam generator. By causing the make-up feed water to pass through two salts-removing plants arranged in series the main salts-removing plant acts as a protection for the steam generating plant in the event of inadequate purification of the make-up feed water in the auxiliary plant *K*. Thus, not only is the steam generating plant protected against the harmful effect of salts in the condensate but is also protected against insufficient purification of the make-up water by the auxiliary salts-removing plant *K*. In addition to the condensate originating from the turbine *A*, other condensates could be used as the boiler feed water, such as the condensates provided in large quantities in the heating or cooling operations of many chemical processes. If such additional condensates are likely to be contaminated with salts they can be introduced through the make-up feed water pipe *J*.—*December* 29, 1954.

721,099.—May 11, 1953.—STEAM PLANTS EMPLOYING ELECTRIC MOTORS, Sulzer Frères Société Anonyme, Winterthur, Switzerland.

The invention relates to steam generating plants, which utilise electric motors for driving auxiliary pumps and blowers. The speed regulation of electric motors is generally carried out by means of control resistances which generate a considerable amount of heat. According to the invention, these control resistances may be used for the generation of steam or for the preheating of fuel oil or furnace air. As shown in the drawing, the path of the water is indicated by a thin, broken line while the path of the steam is shown as a full, thick line. The feed water is supplied by a high-pressure pump *A* to the main boiler *B*. The steam generated flows to the turbine *C* which is coupled to the generator *D*. Exhaust steam from the turbine passes to the condenser *E* and the condensate flows into a collecting vessel *F* from which the feed pump draws its supply. The cooling water used in the condenser is vaporised there into secondary steam and is then superheated in the superheater *G*. The electric heaters which, according to the invention, comprise the resistances to control the auxiliary motors, are indicated at *H*, *J*, *K* and *L*. The heater *H* is an immersion heater, in a small boiler, which generates an additional supply of high-pressure steam at, say, 80 atmospheres. This is supplied to the main boiler *B* through the water separator *M*. Alternatively, or in addition, a further heater *J* can be employed, which is fed with water tapped off from the secondary feed pipe and which vaporises this water and provides an additional supply of low pressure steam which is injected into the secondary steam pipe leading from the condenser *E*. It is also possible to provide a heater *K* for



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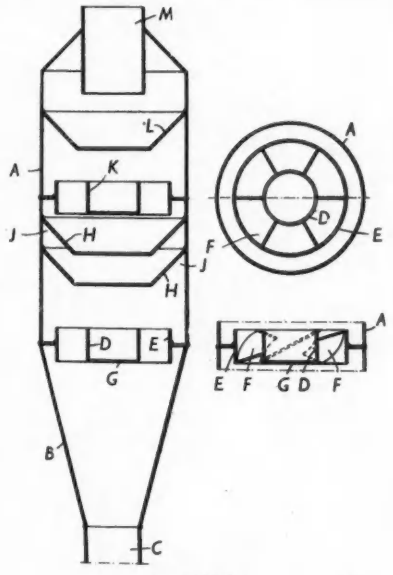
vaporising and superheating the condensate in the closed circuit of the secondary steam superheater *G* to generate steam at, say, 40 atmospheres absolute pressure. A heater *L* can also be used for preheating the feed water to the main boiler, while in a similar manner, the feed water to the main boiler, or the oil fuel for the boiler, or both, may be preheated by a resistance heater. In this way all the control resistances for the electric motors driving the auxiliary plant may be arranged to serve as heaters for each of the fluids used in the steam generating plant.—*December* 29, 1954.

INTERNAL COMBUSTION ENGINES

720,940.—April 9, 1953.—SPARK EXTINGUISHERS AND/OR ARRESTERS, Aktiebolaget B.A. Hjorth and Co., Enköping, Sweden.

In the drawing, *A* is a cylindrical casing connected by a conical part *B* at its lower end with an inlet *C* to the exhaust pipe of the engine. At the lower end of the casing a guide blade means is arranged and comprises two concentric rings *D* and *E* between which guide blades *F* are provided, the blades imparting a rotary motion to the inflowing exhaust gases. The inner ring *D* has a closed end *G* to face



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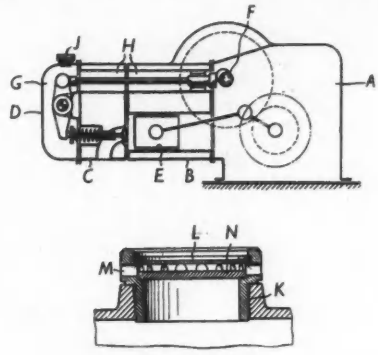
the inlet and prevent the gases from flowing straight through the ring. Furthermore, partitions *H* are provided above the guide blade, each partition consisting of a downwardly directed frustum of a cone in order to form annular, downwardly open pockets *J*, the smallest diameter being less than the greatest diameter of the ring *E*. A further guide blade *K* is arranged following the two partitions, this being constructed in the same way as the first, and above this a further partition *L*. At the upper end of the casing an axial outlet *M* is provided. The invention is not limited to the embodiment shown and described but the same may be varied in many ways within the scope of the invention.—*December* 29, 1954.

721,021. July 6, 1953.—MEANS FOR VENTING AN ENGINE CRANKCASE, Daimler-Benz Aktiengesellschaft, Stuttgart-Unterturkheim, Germany.

The invention comprises improvements in means for venting the crankcase of an internal combustion engine and is particularly applicable to a single-cylinder horizontal engine. In the drawing, *A* is the end part of the crankcase, *B* the cylinder block, *C* the cylinder head and *D* a valve hood. The piston *E* is connected with the crankshaft, which in turn is geared with a camshaft *F* controlling the valve through the pusher rod and rocker as shown. The end part *A* of the crankcase is in open communication with the space *G* within the valve hood *D* through the duct *H* containing the push rods. The non-return valve *J* on the hood *D* consists of a valve housing *K* which is screwed into a threaded bore in the hood and has a large bore which is closed

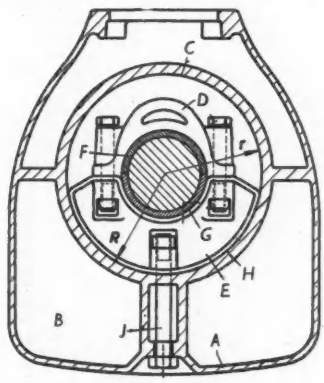


No. 721,021

towards the outside by a closure plate *L*, the position of which is fixed by means of a securing ring and is in communication with the atmosphere through radial bores *M*. Beneath the radial bores there is machined a seat surface for a valve plate *N*. On the outward stroke of the piston the valve plate is lifted and pressed against the closure plate in consequence of the super-atmospheric pressure produced in the crankcase and communicated to the hood *D* through the duct *H*. The valve is thus opened and the excess pressure can escape to the atmosphere through the radial bores *M*. During the following inward movement of the piston the valve plate is pressed on to its seat and closes the interior of the engine against the atmosphere. In this way an average sub-atmospheric pressure of for example, about 200mm water column can be produced in the crankcase during all strokes. The air current passing out of the crankcase through the valve undergoes several changes of direction on its course, namely, firstly, at the inlet into the passage *H*, or at least on passing out of the passage and, finally, again on passing through the valve bores *M*, which has the result that the heavier lubricating oil vapour or particles is or are deposited in the chamber *G* in an amount possibly sufficient for the lubrication of the valve control parts.—*December* 29, 1954.

720,889. April 16, 1953.—CRANKSHAFT BEARING, FERDINAND PORSCHE, of German nationality, partner of the firm, Dr. Ing. h.c.F. Porsche K.—G., of Neckarsulmer Strasse, 85, Stuttgart-Zuffenhausen, Germany, and Aligaier Werkzeugbau G.m.b.H., Uhingen Wurttemberg, Germany.

As the drawing shows, the crankcase *A* has an intermediate wall *B* for each bearing point of the crankshaft, with a bore *C*. In this bore is mounted a bearing body consisting of an upper part *D* and a lower part *E*, connected together by means of bolts as shown and bearing bushes *F* and *G*, in which the



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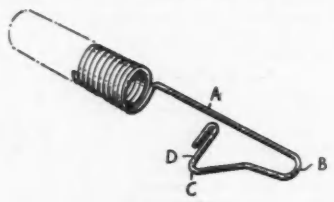
crankshaft is supported. The lower part *E* of the bearing body is seated in the bore *C* along a contact surface *H* of which the length is less than one-half of the circular circumference of this bore. The

radius *R* of this curved contact surface *H* is greater than the radius *r* of the bore *C* by an amount corresponding to a force fit. The remaining parts of the bearing body are so low that the clearance space left in the bore between them and the periphery of the bore is adequate for sliding the crank shaft in together with the bearings. As a result of the smaller curvature of the contact surface, during assembly the ends of these contact surfaces first of all come into contact with the bore *C*. By means of a bolt *J* this body is now pressed into the bore in a radial direction, whereby full and satisfactory contact of the bearing body is produced. The bolt at the same time secures the bearing body against axial and radial movements. The construction of the bearing is also described in the specification.—*December* 29, 1954.

SPRINGS

720,973. May 27, 1953.—COILED TENSION SPRINGS, Rex Trewartha, "Westview," St. Piran's Road, Perranporth, Cornwall.

The invention relates to springs, and more particularly to coiled tension springs, and it has for its object to provide improved means for attaching the ends of such springs to their anchorage points. The drawing shows perspective views of one end of a coiled tension spring having an end attachment according to the invention, the loop of the attachment being shown in the open and the closed positions. Referring to the drawing, the wire of which a coiled tension spring is formed has an end portion including a shank *A* extending axially of the spring, a "U"-bend at *B* and a further bend at *C* such that the part *D* of the wire beyond the bend lies transversely of and substantially perpendicular to, and extends towards, the shank *A*. The extremity of the part *D* is bent back on itself to form a hook for engaging the shank. The loop can be readily opened by pressing the two sides towards each other for disengaging the hook from the shank. The side of the loop opposite to the shank is preferably inclined outwardly away from the shank towards the bend *E*.—*December* 29, 1954.



No. 720,973

Launches and Trial Trips

HAMINA, cargo ship; built by John Lewis and Sons, Ltd., for A/S William Hansen Rederi II, Norway; length overall 305ft, length between perpendiculars 275ft, breadth moulded 44ft, depth moulded 21ft 9in, deadweight 3016 tons, gross tonnage 2408 tons; two holds, four hatches, eight 5-ton derricks, electric deck machinery, three 150kW and one 25kW diesel-driven generators; Lewis-Doxford oil engine, 1450 b.h.p. at 145 r.p.m. Trial, December 22nd.

PINEMOOR, cargo liner; built by the Burntisland Shipbuilding Company, Ltd., for Johnston Warren Lines, Ltd.; length between perpendiculars 345ft, breadth 52ft 7in, depth moulded to shelter deck 32ft 4in, draught loaded 21ft 9½in, deadweight 4900 tons; twelve passengers; four holds, one deep tank, steam deck machinery; Hawthorn-Doxford oil engine, four cylinders, 600mm diameter by 2320mm combined stroke, 3300 b.h.p. Launch, December 28th.

ESSO EXETER, oil tanker; built by Vickers-Armstrongs, Ltd., at Walker Naval Yard, for the Esso Petroleum Company, Ltd.; length between perpendiculars 600ft, breadth moulded 82ft 6in, depth moulded 42ft 6in, deadweight 26,650 tons; thirty cargo oil tanks, one main cargo pump room; one set of Parsons geared turbines, 13,750 s.h.p. at 115 r.p.m. of propeller, two Babcock and Wilcox boilers. Launch, January 5th.

Catalogues

THE CAPE ASBESTOS COMPANY, Ltd., 114–116, Park Street, London, W.1.—Leaflet describing compressed asbestos-fibre-jointing.

MAX ARC AND ELECTRICS, Ltd., Terrace Road, Walton-on-Thames, Surrey.—Leaflet describing the Max Arc "300" oil-cooled welder.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., Trafford Park, Manchester, 17.—Copy of the Metrovick pocket electrode guide.

BROOKES AND WALKER, Ltd., 47, Great Eastern Street, London, E.C.2.—Leaflet illustrating and describing Taylor screw and plain plug and ring gauges.

F. J. EDWARDS, Ltd., Edwards House, 359–361, Euston Road, London, N.W.1.—Booklet describing and illustrating "Besco" sheet metal-working machines.

INTERNATIONAL COMBUSTION, Ltd., 19, Woburn Place, London, W.C.1.—Publication No. G.534, "Ore Reduction with the Hardinge Conical Ball Mill."

H. W. SULLIVAN, Ltd., Leo Street, Peckham, S.E.15.—Catalogue, "Standards and Measuring Equipment for Electrical Research and Telecommunication Engineering."

THE ACRU ELECTRIC TOOL MANUFACTURING COMPANY, Ltd., Chapel Street, Stockport Road, Levenshulme, Manchester, 19.—Leaflet on the Acru "Pyrolit" cellophane sealing iron.

ROYCE ELECTRIC FURNACES, Ltd., Sir Richards Bridge, Walton-on-Thames, Surrey.—Two illustrated publications describing controlled atmosphere furnaces and forced air circulation ovens.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Jan. 26th.—LONDON SECTION: School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "A Survey of Tuner Designs for Multi-Channel Television Reception," D. J. Fewings and S. L. Fife, 6.30 p.m.

CHEMICAL SOCIETY

To-day, Jan. 21st.—CAMBRIDGE SECTION: Chemical Laboratory, The University, Cambridge, "Recent Advances in Acetylene Chemistry," R. A. Raphael, 8.30 p.m.

ENGINEERS' GUILD

Wed., Jan. 26th.—W. MIDLAND BRANCH: Engineering Centre, Stephenson Place, Birmingham, "Human Relations in Industry," R. Bramley-Harker, 6.30 p.m.

HULL CHEMICAL AND ENGINEERING SOCIETY

Tues., Jan. 25th.—Church Institute, Hull, "The Manufacture of Steel Tubes," L. C. Hackett, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Jan. 24th.—LEICESTER CENTRE: Demonstration Theatre, E. Midlands Electricity Board, Charles Street, Leicester, "Contemporary Lighting," K. S. Morris, 6 p.m.——LEEDS CENTRE: E.L.M.A. Lighting Service Bureau, 24, Aire Street, Leeds, 1, "The Use of Films in the Textile Industry," Frank Hill, 6.15 p.m.

Fri., Jan. 28th.—BATH AND BRISTOL CENTRE: S.W. Electricity Board, Old Bridge Street, Bath, "Lighting for Photography," R. W. Unwin, 7 p.m.——BIRMINGHAM CENTRE: "Regent House," St. Phillips Place, Colmore Row, Birmingham, Symposium, "Shop Window Lighting," R. C. Pennington; "Colour in Interior Decoration," J. B. Hornblow; "Aspects of Industrial Lighting," F. C. Johnson; "Aspects of Museum Lighting," N. W. Bertenshaw, 6 p.m.

Mon., Jan. 31st.—LEEDS CENTRE: Lecture Theatre, Yorkshire Electricity Board, Ferensway, Hull, "Prescribing for Seeing," M. L. Berson, 7.30 p.m.

INCORPORATED PLANT ENGINEERS

Mon., Jan. 24th.—MERSEYSIDE AND N. WALES BRANCH: Radiant House, Bold Street, Liverpool, "Planned Maintenance as a Contribution to Higher Productivity," A. J. Speakman, 7.15 p.m.

Thurs., Jan. 27th.—SHEFFIELD AND DISTRICT BRANCH: Grand Hotel, Sheffield, "Factory Flooring Problems," A. E. Rice, 7.30 p.m.

Fri., Jan. 28th.—BIRMINGHAM BRANCH: Imperial Hotel, Birmingham, "Auto Controls for Plant," M. C. Rogers, 7.30 p.m.

Mon., Jan. 31st.—W. AND E. YORKS BRANCH: The University, Leeds, "Reclamation of Worn Parts: Metal Spraying," 7.30 p.m.

INSTITUTE OF FUEL

To-day, Jan. 21st.—SCOTTISH SECTION: Royal Technical College, Glasgow, "The Recovery of Sulphur from Coke-Oven Gas by the Collin Process," T. H. Williams, 7 p.m.

Thurs., Jan. 27th.—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, JOINT MEETING WITH THE COKE OVEN MANAGERS' ASSOCIATION: Paper on "Dutch State Mines," 5.30 p.m.——MERSEYSIDE SUB-SECTION: Liverpool Engineering Society's Rooms, 9, The Temple, Dale Street, Liverpool, "Atomic Energy," J. C. C. Stewart, 7 p.m.

INSTITUTE OF METALS

Thurs., Jan. 27th.—BIRMINGHAM LOCAL SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Diffusion in Metals," A. D. le Claire, 6.30 p.m.

INSTITUTE OF REFRIGERATION

Thurs., Jan. 27th.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "Economic Aspects of Cold Store Design and Operation," G. A. May, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., Jan. 25th.—N.E. ENGLAND GROUP: Royal County Hotel, Durham, "Tyre Development and the Use and Abuse of Tyres," W. R. Good, 7 p.m.

INSTITUTE OF THE MOTOR INDUSTRY

Wed., Jan. 26th.—40, Queen's Gate, London, S.W.7, "Motoring in the New World," George M. Goudie, 7.30 p.m.

INSTITUTE OF WELDING

Fri., Jan. 28th.—BIRMINGHAM BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Influence of Welding on Steel Building Structures," S. M. Reisser, 6 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Sat., Jan. 29th.—MIDLANDS BRANCH: The University, Edmund Street, Birmingham, Annual General Meeting, 2.30 p.m., "The Application of the Continuous Solid Bowl Centrifuge to the Chemical and Allied Industries," G. D. Kelsey, 3 p.m.——N.W. BRANCH: Engineers' Club, Albert Square, Manchester, Annual General Meeting, 2.30 p.m.; "Some Aspects of the Chemical Processes Ancillary to Atomic Energy," Sir Christopher Hinton, 3 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Jan. 25th.—HYDRAULICS MEETING: Great George Street, Westminster, London, S.W.1, "The Employment of Unit Hydrographs to Determine the Flows of Irish Arterial Drainage Channels," J. J. O'Kelly, 5.30 p.m.

Fri., Jan. 28th.—YORKSHIRE ASSOCIATION: Royal Station Hotel, York, "Prestressed Units for Short-Span Highway Bridges," A. D. Holland, 7 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Jan. 24th.—RADIO SECTION: Savoy Place, London, W.C.2, "Radio Aids to Marine Navigation," F. J. Wylie, 5.30 p.m.

Wed., Jan. 26th.—SUPPLY SECTION: Savoy Place, London, W.C.2, "Sealed Transformers," E. B. Franklin, 5.30 p.m.

Thurs., Jan. 27th.—FARADAY LECTURE: Central Hall, Westminster, London, S.W.1, "Courier to Carrier in Communications," T. B. D. Terroni, 6 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Wed., Jan. 26th.—W. OF SCOTLAND BRANCH: St. Enoch Hotel, Glasgow, "The Application of Plastics in General Engineering," Herbert Winning, 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Jan. 25th.—39, Elmbank Crescent, Glasgow, "Some Experiments on Oscillating Bearings," F. T. Barwell, A. A. Milne and J. S. Webber, 7.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Jan. 21st.—1, Birdcage Walk, Westminster, London, S.W.1, Thomas Lowe Gray Lecture, "Some Factors in the Selection of Machinery for Cargo Liners," L. Baker, 5.30 p.m.——YORKSHIRE BRANCH: The University, St. George's Square, Sheffield, James Clayton Lecture, "The Theory of Plasticity: Recent Achievements and Future Problems," William Prager, 6.30 p.m.

Mon., Jan. 24th.—YORKSHIRE BRANCH: Technical College, Bradford, "Planning a Modern Factory," C. M. Dolezalek, 7 p.m.

Tues., Jan. 25th.—N.W., A.D. CENTRE: University of Liverpool, Walker Buildings, Brownlow Hill, Liverpool, "Recent Developments in the Road Transport and Handling of Bulk Sugar," C. H. Williams, 7.15 p.m.——LONDON GRADUATE SECTION: 1, Birdcage Walk, Westminster, London, S.W.1, "Mechanical Equipment Used in Gold Mining," I. Witt, 6.30 p.m.

Wed., Jan. 26th.—APPLIED MECHANICS' GROUP DISCUSSION: 1, Birdcage Walk, Westminster, London, S.W.1, "Principles Underlying the Choice of Working Stresses and the Extent to which Pasticity can be Used in Design," 6.45 p.m.

Thurs., Jan. 27th.—EASTERN BRANCH: Great White Horse Hotel, Ipswich, "Inspection, Explosion and Breakdown of Boilers and Pressure Vessels," J. Eyers, 7.30 p.m.——WESTERN A.D. CENTRE: Royal Hotel, Bristol, "Production Problems in Commercial Vehicle Manufacture Caused by New Models," D. L. Campbell, 6.45 p.m.

Fri., Jan. 28th.—GENERAL MEETING, EDUCATION GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Co-operation in Engineering Research between Educational Institutions and Industry," E. Giffen, V. C. Davies and F. H. R. Nixon, 5.30 p.m.

Mon., Jan. 31st.—E. MIDLANDS BRANCH: Rolls-Royce Welfare Hall, Nightingale Road, Derby, "Rocket Propulsion," A. D. Baxter, 7 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Wed., Jan. 26th.—INFORMAL MEETING: Conference Room, Fourth Floor, Waterloo Bridge House, London, S.E.1, "London Trunk and Toll Exchanges: Their Functions and Future," R. C. Devereux, 5 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Tues., Jan. 25th.—LANCASHIRE AND CHESHIRE BRANCH: College of Technology, Manchester, "Modern Architecture," T. Howarth, 6.30 p.m.

Thurs., Jan. 27th.—11, Upper Belgrave Street, London, S.W.1, "Brittle Fracture Problems in Steel Construction," G. M. Boyd, 6 p.m.

Fri., Jan. 28th.—MIDLAND COUNTIES BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Influence of Welding on Steel Building Structures with Particular Reference to Erection," S. M. Reisser, 6 p.m.

Mon., Jan. 31st.—WALES AND MONMOUTHSHIRE BRANCH: S. Wales Institute of Engineers, Cardiff, "Simple Plastic Theory," B. G. Neal, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Jan. 21st.—INFORMAL MEETING: Pepys House, 14, Rochester Row, London, S.W.1, "Delegation of Responsibility and Authority," A. S. Trollip, 7 p.m.

Fri., Jan. 28th.—INFORMAL MEETING: Pepys House, 14, Rochester Row, London, S.W.1, "Tubular Structure," E. McMinn, followed by Film, "The Tubewright," 7 p.m.

LIVERPOOL ENGINEERING SOCIETY

Wed., Jan. 26th.—24, Dale Street, Liverpool, "Stress Investigation by Model Tests and Analogues," M. L. Meyer, 6 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Jan. 28th.—Mining Institute, Neville Hall, Newcastle upon Tyne, "Some Effects of Blade Section Shape on Model Screw Performance," A. Silverleaf and T. P. O'Brien, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., Jan. 25th.—SCOTTISH BRANCH: North British Hotel, Princes Street, Edinburgh, "Recent Developments at Rothes Colliery, Fifeshire," N. S. Landale and J. Maude, 6.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Jan. 25th.—GRADUATES' AND STUDENTS' SECTION: 4, Hamilton Place, London, W.1, "Test Flying a V-Bomber," H. G. Hazelden and R. H. Williams, 7.30 p.m.

Thurs., Jan. 27th.—SECTION LECTURE: 4, Hamilton Place, London, W.1, "Dynamic Problems of Interplanetary Flight," D. F. Lawden, 7 p.m.

ROYAL SANITARY INSTITUTE

Wed., Jan. 26th.—LONDON SESSIONAL MEETING: 90, Buckingham Palace Road, London, S.W.1, "Air Pollution," Sir Hugh Beaver, 2.30 p.m.

ROYAL SOCIETY OF ARTS

Wed., Jan. 26th.—CADMAN MEMORIAL LECTURE: John Adam Street, Adelphi, London, W.C.2, "Research in the Coal Industry," W. Idris Jones, 2.30 p.m.

SOCIETY OF INDUSTRIAL ENGINEERS

Fri., Jan. 28th.—Engineers' Club, Albert Square, Manchester, "A Case History," H. D. J. Kerse, 7 p.m.